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AND
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A MONTHLY JOURNAL FOR ENGINEERS, ARCHITECTS, SURVEYORS & CONTRACTORS and all interested in CEMENT, CONCRETE, REINFORCED CONCRETE, FIRE-RESISTING CONSTRUCTION and STRUCTURAL STEEL.

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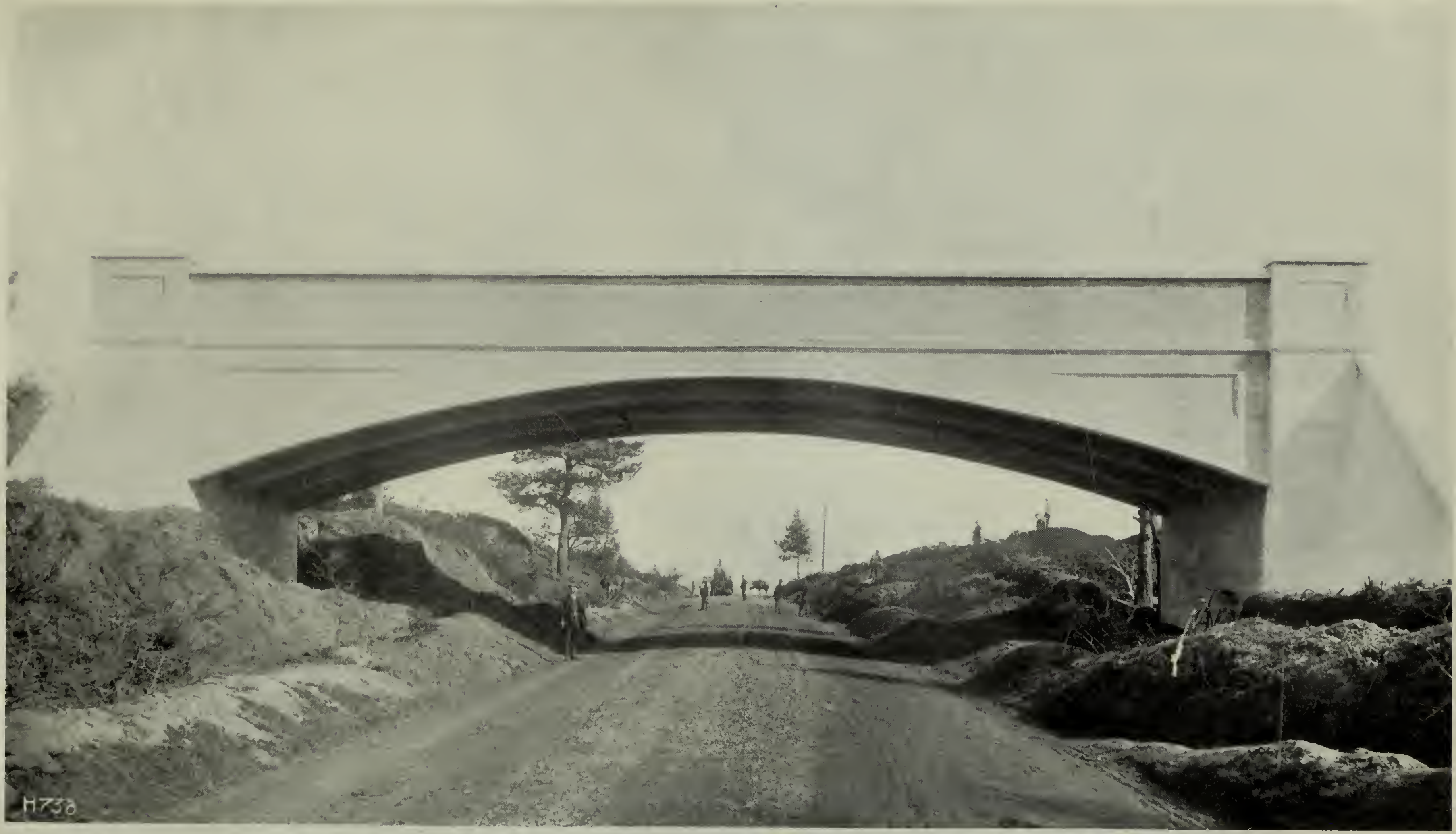

View of finished Structure.
Reinforced Concrete Bridge at Ringwood Road, Wimborne, Dorset.

(Frontispiece.
Opp. Contents.)

CONCRETE
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EDITORIAL NOTES.

ARCHITECTS AND TENDERS FOR REIN FORCED CONCRETE.

WE frequently hear from reinforced concrete " specialist " firms, as also from building contractors, that successful tendering for reinforced concrete work, on the invitation of architects, has become very much a matter of chance. Further, contractors and specialists who are prepared to take undue risks, or have little or no practical experience, are stated to have the advantage over firms of standing who have a reputation to uphold.

The cause of this trouble we find to be due—firstly, to the absence of any specific understanding that certain general conditions as to design and execution are to be observed by the parties concerned ; and, secondly, owing to architects not giving full particulars of the work they require when issuing their requests for designs and prices.

STANDARD CONDITIONS.

As to the general conditions, it should be a simple matter for architects to specify that the rules of the Royal Institute of British Architects are to be strictly adhered to, and the firm tendering should, in writing, be given to understand that there will not only be the supervision by the architect, but also by a consulting engineer ; that specimens of the materials provided will be tested from time to time, and that work will occasionally be opened up for inspection.

Regarding the absence of particulars, however, we hold that architects' specifications and instructions require more thought and care than architects, as a whole, are wont to give to the subject at present. Many of the instructions issued from architects' offices are crude in the extreme, and quite incomplete, and they, unfortunately, also frequently bear evidence of extraordinary ignorance.

MORE PARTICULARS WANTED.

Of the various letters of complaint received from " specialists," we present below extracts from a well-reasoned communication, which clearly indicate the shortcomings that the contractors have to put up with. Shortcomings of the character named are inexcusable, and are due either to sheer laziness or to that extraordinary ignorance of engineering questions common to so many architects, who look upon their calling solely as an art and not, as they should, as a technical profession. Nor will the artist-architect go to the expense of obtaining proper engineering advice when entrusted with work of an eminently technical character such as, say, a reinforced concrete warehouse.

We should not be going too far in saying that there is scarcely one artist-architect in a hundred who is thoroughly conversant with the essentials for a specification of structural engineering work, whilst the few who know anything as to the true aspects of reinforced concrete are necessarily even rarer. Unfortunately, even when desirous of obtaining information on the subject which is a comparatively new one, they are hampered by an absence of reliable data, for, with the exception of those of the Royal Institute of British Architects, or those to be found in a journal such as ours, there are only a few books available —for the most part of the "scissors and paste" order—and the catalogues issued by interested parties.

INDEPENDENT CONSULTANTS.

This absence of information, and of suitable literature, however, makes the shortcomings of the architects no less inexcusable, for there is ample engineering advice available outside the ranks of the "specialists," and any sensible building employer will, as a rule, either bear the whole expense or contribute towards a consulting fee if the architect tells him that a civil engineer should also be engaged on the work. Even if an architect cannot obtain the engineering assistance he desires, there is no reason why he should not, however, be able to provide fuller data than he often gives at present. The "specialists" or contractors who are preparing designs and tendering have a right not only to complete data, but also to absolute equality as to the information issued.

It is, of course, natural that there should still be much lacking in the proper relation between architect, specialist and contractor on a subject so new to this country as reinforced concrete. Thus it would be well if some of the institutions concerned, as for instance the Concrete Institute, were to set to work to prepare and issue some short, useful code as to the points of importance in actual practice of design, in the preparation of drawings, conditions of tendering, specifications, quantities, and in the conditions of supervision and tests. The equitable principles of every-day practice want codification.

CHARACTERISTIC COMPLAINTS.

The letters which have been the direct cause of the above remarks contain well-merited strictures upon the laxity of architects in matters relating to reinforced concrete. The extracts from some of them given below should be interesting reading. For obvious reasons our correspondents desire to remain unnamed.

No. 1. PARTICULARS AS TO SUPERLOAD.

"We often receive from architects a general design of a building, for which we are asked to provide reinforced concrete floors without any indicated superload, which means that we have to write for information, and wait until we have received same until we can proceed with the scheme. This means a loss of time to the architect, to the contractor, and to ourselves, and it has the effect, in certain cases, of preventing our getting out our scheme within the time specified by the architect.

"The lack of this particular information, however, has another serious disadvantage, namely, that in competition, if the designers are left to provide the superload themselves, they will, in all probability, provide for different loads, and as the cost of a reinforced concrete floor is much affected by the weight of the superload, there is a resulting discrepancy in the prices, which are not, of course, all upon the same basis.

"We also find that in certain cases the information concerning the load to be carried by the floors of a building is meant by the architect to embody the actual dead load of the floors. A misunderstanding on such a vital point is, of course, fatal, but we have known it to occur.

"While we are on the subject of superloads, we may mention that not infrequently we have been requested by architects to provide for a test load of 100 per cent. in excess of the superload which they indicate, and they stipulate that this test must not produce any permanent set in the beams. Our contention is that this is practically an impossibility, and as you are no doubt aware, the tests of floors of constructions in reinforced concrete, in a general sense, are not usually made with more than 50 per cent. of the superload."

No. 2. PARTICULARS AS TO GROUND.

"Another point of vital importance, which seems to escape the notice of a considerable number of architects, is the necessity of specifying the bearing capacity of the ground, or thinking it sufficient to simply state the nature of the same, leaving the specialist designer to provide whatever he thinks fit. Obviously, this has the same result in competitive designs as the above-mentioned question of superloads, namely, that the schemes are not all on the same basis.

"The bearing capacity of the ground should be given by the engineer or architect of the work in tons per sq. ft., and if there is any doubt about this question, a practical experiment should be made by loading up the ground.

"We may say here that the question of the bearing capacity of the ground does not appear to us to be given sufficient attention, and we have frequently found that either the ground would stand very much more than the amount specified, or else that the ground is assumed as capable of a greater resistance than what is actually confirmed by the results obtained after the building has been erected."

No. 3. THE FACTOR OF SAFETY.

"We frequently find that no factor of safety is stated by the architect, or working stresses for the steel and concrete, nor are we asked to apply, for our calculations, the rational methods as applied to the strength of materials, or as stated by the Reports of the Royal Institute of British Architects, so that the scheme of one firm of specialist reinforced concrete designers may be compared, by the architect, with the scheme of another firm, where there should not be any comparison possible, owing to the fact that one of the firms may have prepared its scheme by applying the rational methods, which may be mathematically proved, and also the working stresses for the steel and concrete approved of by the usual rules and practice established by experts, whereas the other firm may have simply employed empirical formulæ, which cannot be rationally proved, or higher working stresses for the materials than those established by the ordinary rules of the profession."

No. 4. MOVING LOADS.

"It is not unusual for an architect to state that the structure will have to carry a moving load of a certain number of tons without giving us the wheel base, or if the so-called wheel base is given the distance between the wheels is not given, or the width of the rim of the wheel is not mentioned, or sometimes we are told that the work will have to stand the load of a crane without any further particulars as to weight or anything else."

AN ATTEMPT TO DISPARAGE REINFORCED CONCRETE.

ADVERSE criticism from one who is feeling the pinch of competition is at so great a discount, and is so open to retaliation, that we should have thought any trade journal in England would have had better sense than to adopt a policy that is more often seen in newer countries. Therefore, we deplore the fact that our esteemed contemporary, *The British Clayworker*, in its November issue, should have fallen from grace in attacking a material that sometimes enters into competition with clay products, in an article entitled " Some Disadvantages of Reinforced Concrete : Its Comparison with Brick Construction." Perhaps it has been thus led astray by seeing the violent diatribes of journals devoted to clay interests that are published in the United States. We should ignore the article were it not that mud sometimes sticks, and we feel it our duty to remove it. At all events, we do not propose emulating the paper in question by retorting with a recital of some of the disadvantages of brick and terra-cotta.

Our contemporary gives away his case at the beginning by admitting that the use of reinforced concrete may be justified in the case of reservoirs, retaining walls, and works of like nature, and by admitting that " the economy and efficiency of reinforced concrete for such purposes as floor slabs and flat roofs is unquestioned," but " the weightiest objections, with few or no corresponding advantages, tell against its use in building construction." It is, at any rate, something to have a clay exponent admit that for floors and roofs reinforced concrete possesses the advantages of economy and efficiency. Our contemporary, after that lucid introduction, then seems to get a little mixed, for it talks next about " ineffectiveness from an architectural standpoint and unsuitability as a weathering material alone," and that it " cannot compete as regards time, and rarely as regards cost, with steel and brickwork construction," and goes on to assert that " from an engineering point of view, the theory (as applied to building construction) is open to criticism," because of questions of indeterminate stresses due to variations in temperature and slight inequalities in settlement. Its chief aim appears then to argue in favour of brick walls, and it drags in steelwork construction, and rushes headlong, illogically, to deny the economy it has already admitted.

We can hardly accept our contemporary as an authority on structural engineering—clay experts cannot be thus reproached—so we can understand it, in ignorance, making that reservation about " building construction " not being the subject of the same engineering theory. We—poor mortals —imagined that the science of engineering applied equally to all structures, and that buildings contained the same problems of design as other work to the construction of which reinforced concrete is applied. Our contemporary is really enlightening when it says : " In fact, engineering calculations cannot be made with anything approaching a degree of precision with steel-frame design. A great deal must consequently be left to the judgment of the designer, which in itself constitutes a grave source of danger, not to mention the endless controversy it is likely to occasion." We are glad to learn that the structures our contemporary admires were not the subject of judgment on the part of their designers—designers should beware of the exercise of judgment, it is " a grave source of danger "—not to speak of " controversy."

Speed in construction is not, as is asserted, in favour of steel-frame construction. There are, one would have thought, sufficient examples to have almost warranted an assertion to the exact reverse, generally speaking.

Again, reinforced concrete columns are usually smaller than fireproofed steel ones, and reinforced concrete is usually less bulky than protected steelwork, and girders can be made as shallow, and often shallower, than steelwork.

Our contemporary does not appear to have heard of T-beam construction, nor of compressive reinforcement in beams.

Then follows a recital of the difficulties of constructing reinforced concrete, with the many points requiring careful workmanship. Evidently a specification for reinforced concrete has been studied. One would almost have thought that our contemporary would have expressed surprise that work requiring so much detailed consideration could have been done with economy, and have competed so strongly as it evidently does with brickwork. But, perhaps, in its privacy it has compared that specification with one for similar brickwork and steel-frame construction, which really would go into as much, and perhaps more, detail, and required much the same materials with just as many points for anxious consideration in order to ensure efficiency. We can only suppose it has forgotten that one construction is as complicated as the other, with restrictions and regulations that must have proper attention in order to secure good workmanship. Architects and engineers find it as necessary with the one as with the other to have a watchful clerk of works.

As regards weathering, concrete can be as badly made as bricks, but there are numerous examples of concrete executed by the Romans which are in a fair state of preservation, and the Portland Cement of to-day is far superior to Roman lime and puzzolana.

We call the attention of our contemporary, who finds it " difficult to conceive how concrete can even be made impervious to water," to the fact that water tanks, aqueducts, and high-pressure water mains of reinforced concrete are known.

Fire resistance is, we agree, an important subject, and we can point to the reinforced concrete buildings which have been subjected to trial, along with brick and steel-frame structures, in numerous large conflagrations as evidence. We only ask for the impartial consideration of the *facts;* we are content to leave it at that, for we believe in theory being based upon facts, and not in theory being used to disguise facts.

We are glad our contemporary finds consolation in concluding by saying : " Having regard to all these circumstances, it would appear that brickmakers have no reason to fear the extensive use of reinforced concrete in the near future." We, too, find consolation in learning that our contemporary thinks as we do that concrete will be extensively used in the near future, and, we might add, as it is being used at present.

BOGUS EXPERTS IN REINFORCED CONCRETE.

Various communications have reached us, particularly from the provinces, as to the necessity of protecting the building owner from what we would term the bogus experts in reinforced concrete.

As in the old days of the introduction of electricity, when every country plumber thought he might safely undertake electric wiring, so to-day all manner of people seem to be confident in their ability to either design reinforced concrete work or to execute it.

Where the highly skilled civil engineer of repute fears to tread in matters of design, the less responsible, and frequently entirely irresponsible failure in the engineering profession seems to be prepared to take upon himself the solution of the most difficult problems of reinforced concrete design. Far be it from us to wish to infer that there are any great secrets in the designing of reinforced concrete work. Any well-trained civil engineer should be able to master the subject for all practical purposes in a year, but this does not mean that any unsuccessful civil engineer can master the subject in that time, or that he is at all a suitable person to take up designing of this responsible description.

What is, perhaps, a more serious matter is the danger of the incompetent contractor who puts in "cutting prices" when tendering and knows little or nothing about the character of the work for which he is competing.

The extraordinary note-paper headings that find their way into this office would be amusing were there not a very serious aspect to the question. Just as there are, in quite a number of cases, gentlemen describing themselves as "architects, surveyors, engineers, concrete specialists, estate agents, auctioneers and undertakers," we have on the industrial side firms describing themselves as "painters, decorators, builders and concrete contractors," and sometimes even as "coal merchants and concrete specialists," and various other curious combinations.

The matter is one which should have the careful attention of the professions and industries concerned. We hope it will be possible later on for a society such as the Concrete Institute to do something in the matter. It is, in any case, an extremely difficult problem, as only a certain proportion of civil engineers and architects belong to the Institution of Civil Engineers and the Royal Institute of British Architects respectively, and there is nothing in the building trade that would be the counterpart of, say, the licensed plumber.

It is, however, to be hoped that some means will be found to protect the building owner as far as possible from bogus specialists and ignorant contractors, and it is certainly a matter that should have early attention, if the use of reinforced concrete is to become thoroughly popular.

WATERPROOFING CONCRETE.

(Contributed.)

As a great deal of attention has been given from time to time to the subject of the waterproofing of concrete, the article we are now publishing should prove of great interest. There are very many divergent opinions on this subject, and we shall gladly open our columns to correspondence in connection therewith.—ED.

In the May, 1908, and July, 1910, issues of Concrete and Constructional Engineering there appeared articles on the subject of the waterproofing of Portland cement concrete. The conclusion arrived at in the article in the May, 1908, issue rather indicated that the writer (Mr. W. Laurence Gadd, F.I.C.) was of the opinion that if the aggregate was properly proportioned and graded so as to give a very dense concrete with practically no voids, as good or better results would be obtained than by the use of any of the so-called " waterproofing compounds " which are put upon the market from time to time—many of which very quickly disappear from view and are never heard of again.

The basic principle in most of these compounds is the same—viz., the use of hydrated lime with a lime soap or similar water repellant material—and in considering the opinion expressed by Mr. Gadd, it should not be forgotten that the very nature of such substances mitigates against their successful application; that is to say, when the water repellant compound is mixed with the cement in the form of a dry powder before water is added. The natural tendency upon the addition of water is for the particles of compound to be expelled from portions of the concrete and collected into little masses here and there—even distribution under such circumstances being practically impossible. The advocates of the compounds which are to be mixed with the water before addition to the concrete claim that even distribution is insured by the use of their materials, but the same objection would appear to apply, with even stronger force, in this case. The particles of solid matter which are mixed with the water do not enter into solution with it, but are merely suspended therein; the liquid therefore acts only as a vehicle for conveying them into the concrete, where they become irregularly deposited.

The subject is one which has claimed a considerable amount of attention of recent years in all countries, and many more or less exhaustive experiments have been carried out at various testing laboratories. At the Annual Meeting of the American Society for Testing Materials, which was held at Atlantic City at the end of June last, the report of Committee D–8 on Waterproofing was submitted. This stated that a large number of tests had been separately made by several members of the Committee. It was admitted that laboratory methods for the study of this class of materials were necessarily somewhat different from their practical application on a large scale, but several facts were, in the Committee's opinion, established from such examinations. It was the Committee's conviction that the general effect of these incorporated compounds was to reduce the strength of mortars. They were further of opinion that resistance to water penetration in mortars and concrete being essentially dependent upon the density of such materials, imperviousness could easily be assured by proper proportioning of the normal ingredients. When, through lack of proper proportioning, extraneous material was needed to ensure void filling, this could be accomplished by the use of natural materials such as colloidal clays or hydrated limes, and practically perfect results obtained.

The Sub-Committee in charge of the investigation of the use of bituminous materials applied directly to the surface, or through cloth or similar mediums, had also inaugurated a series of tests. Concrete tanks were protected by six different proprietary materials or methods of protective coating, and thereafter subjected to the influence of four different liquids. The tanks had been regularly inspected and records kept. Several had failed, but as a final examination had not yet been made, no further report could then be presented.

This report by the Sub-Committee of the American Society practically confirms the opinion expressed by Mr. W. L. Gadd, which has been previously referred to, and also the results so far obtained by a very exhaustive series of experiments now being conducted in an English laboratory, concerning which we give below a summary of a communication from a correspondent.

During the course of experiments, which have been under way for about three years past, the better known " Waterproofing " compounds have been analysed and experimented with, as well as natural materials—both of a water repellant character and those which merely act as " pore fillers." When these tests were first instituted it was found that many of the results obtained were totally conflicting, and investigation proved this to be due to the very great difficulty in gauging to the same degree

ALL SLABS 3 PARTS STANDARD LEIGHTON BUZZARD SAND TO 1 PART CEMENT.

Series.	Waterproofing Material added (to weight of cement only).	First Slab.			Second Slab.		
		Centre c.c.	Sides c.c.	Total c.c.	Centre c.c.	Sides c.c.	Total c.c.
A	Nil	0	1,470	1,470	0	1,010	1,010
B	3 per cent. of mixture of slaked lime and lime soap	5	1,010	1,015	0	1,570	1,570
C	3 per cent. colophony ...	5	580	585	5	930	935
D	3 per cent. dry china clay ...	0	760	760	0	870	870
E	3 per cent. (slaked lime, 90 parts ; colophony, 10 parts)	5	430	435	10	790	800
F	3 per cent. (china clay, 50 parts ; colophony, 50 parts)	0	830	830	0	650	650
G	3 per cent. paraffin wax ...	5	1,000	1,005	5	1,000	1,005
H	3 per cent. (slaked lime, 90 parts ; paraffin wax, 10 parts)	0	640	640	0	510	510
I	3 per cent. alum	5,232	102,760	107.992	4,656	84,960	89,616
K	3 per cent. alumina... ...	5	360	365	10	270	280
L	3 per cent. colophony, 5 per cent. sodium carbonate	10	840	850	10	790	8,000
M	1 per cent. soap	20	1,620	1,640	10	740	750
N	3 per cent. slaked lime ...	0	420	420	0	480	480
P	5 per cent. alumina ...	5	850	855	5	700	705
Q	5 per cent. china clay ...	5	280	285	5	620	625
R	3 per cent ground slate ...	5	170	175	5	330	335
S	3 per cent. burnt gault clay	2	1.800	1,802	3	2.940	2,943
T	3 per cent. (slaked lime, 80 parts ; colophony, 20 parts)	3	520	523	0	60	60
U	3 per cent. (alumina, 90 parts ; wax, 10 parts)	2	225	227	1	215	216
V	3 per cent. (china clay, 90 parts ; wax, 10 parts)	0	405	405	0	120	120
W	3 per cent. resin soap ...	332 006	6,408,000	6,740,006	640.800	4.737.600	5.378,400
X	3 per cent (alumina, 50 parts ; china clay, 50 parts)	41	529	570	0	175	175

of density any two test blocks, even when made from the same materials and under the same conditions. Attention was therefore directed in the first place to this problem, which was successfully solved, and, as a further check, all tests were carried out in duplicate. The blocks tested were 10 in. square and 3 in. thick, and the aggregate used was 3 parts of Leighton Buzzard sand (of the size stipulated in the British Standard Specification for Portland cement) to 1 part of cement, it being found that blocks made with this uniform sand were, when tested without addition of any waterproofing substance, sufficiently porous to allow of a certain amount of water percolating through them—a condition which was essential in order to obtain comparative results.

The slabs or blocks were taken from the moulds 24 hours after gauging and immediately placed in cold water, where they were kept for 20 days. They were then removed and submitted at once to a water pressure of 50 lbs. per sq. in.

The table on the preceding page is a summary showing the quantity of water which percolated through the centre, and also that which found its way out through the sides of slabs—to which had been added during gauging different proportions of various substances—at the above pressure during 24 hours.

A similar series of tests were then made on slabs, in which 3 parts of a well-graded aggregate (all through ¼-in. mesh) were substituted for the standard Leighton Buzzard sand. The following are the results obtained :

WATER PERCOLATED DURING 24 HOURS.

Series.	Waterproofing Material added (to weight of cement only).	First Slab.			Second Slab.		
		Centre c.c.	Sides c.c.	Total c.c.	Centre c.c.	Sides c.c.	Total c.c.
AF	Nil	0	110	110	0	120	120
AB	3 per cent. (china clay, 90 parts ; wax, 10 parts)	0	135	135	0	118	118
AC	3 per cent. (slaked lime, 90 parts ; wax, 10 parts)	2	405	407	2	28	30
AD	3 per cent. china clay ...	0	60	60	0	398	398
AE	3 per cent. slaked lime ...	0	4	4	0	10	10

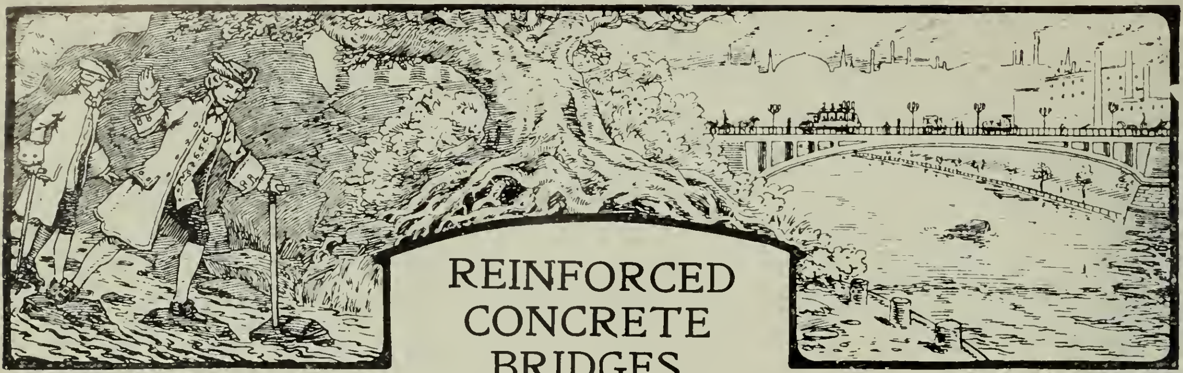
Commenting upon the results given above, and summarising his views generally, our correspondent concludes :

1. The impermeability of concrete is simply a matter of density or closeness of texture. This is arrived at in no other way than by filling the pores of the concrete with finely divided insoluble material, which can be done either by properly grading the aggregate, or by the addition of powdered substances, of which slaked lime and China clay appear to be the two best, and most effective. Slaked lime has, however, a tendency to produce efflorescence on the surface ; China clay has no such tendency.

2. Water repellants, such as greasy substances—lime soap, etc., have no rea waterproofing properties. The waterproof compounds on the market are beneficia only so far as the slaked lime (which forms 90 per cent. of their composition) acts as a pore filler. The 10 per cent., or thereabouts, of lime soap contained in these compounds is a defect rather than an advantage.

3. The action of sea water on concrete is probably entirely due to the permeability, and will be prevented if the concrete is made sufficiently dense and mpervious.

4. The substances used as pore-fillers—especially clays—should be added to the cement or concrete in a *dry* state.



REINFORCED CONCRETE BRIDGES.

One of the principal uses to which reinforced concrete has been put, and in which it has been of the greatest service, is in the construction of bridges. The present examples are, with one exception, taken from Great Britain, and although not of the magnitude of the structures erected in America or on the Continent, they show the increased use of reinforced concrete for bridge work in the British Isles.—ED.

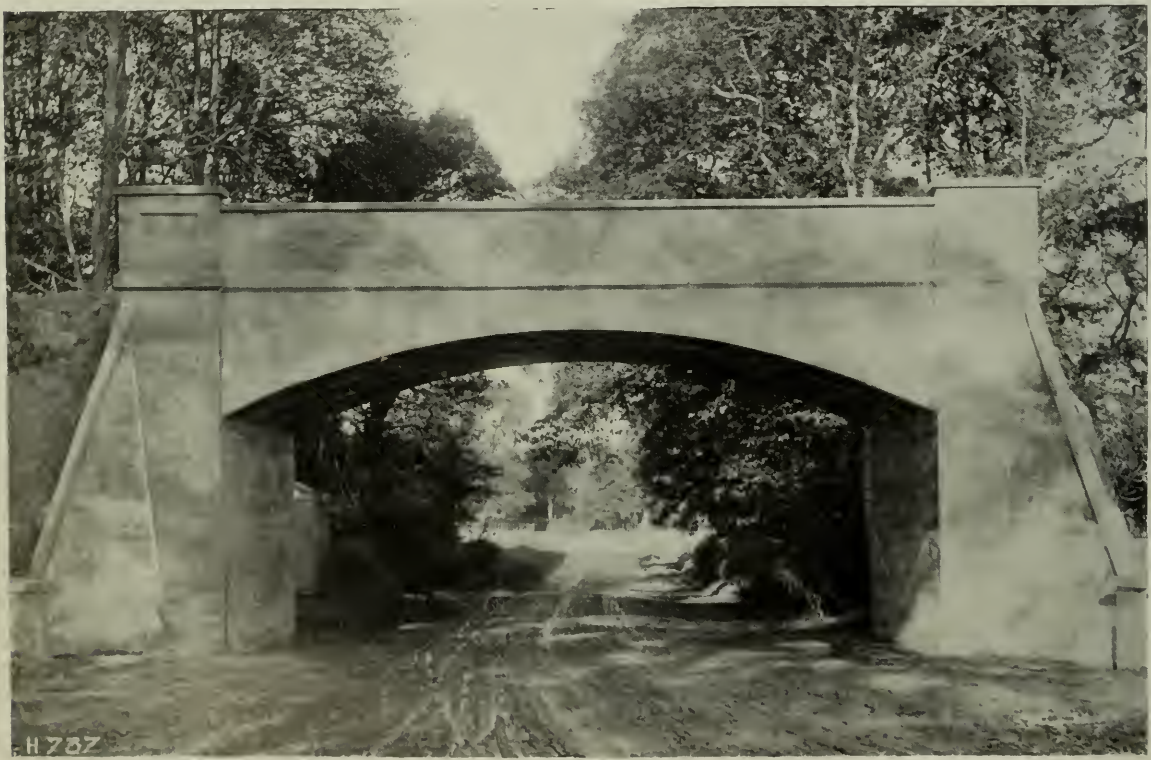
REINFORCED CONCRETE BRIDGES AT WIMBORNE, DORSET.

Two bridges constructed entirely of reinforced concrete were recently erected at Wimborne, Dorset.

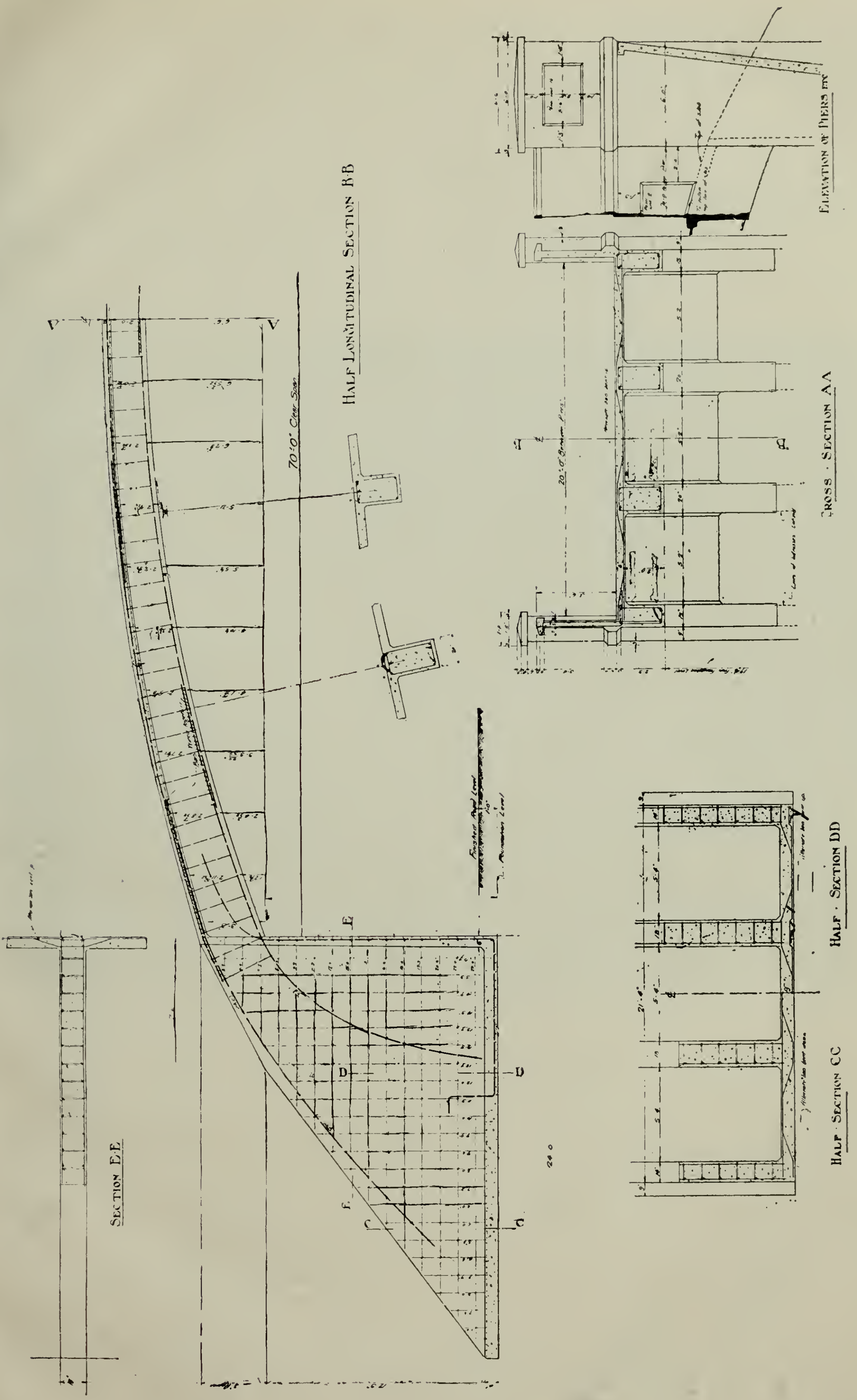
The Ringwood Road Bridge, shown in the frontispiece to this issue, is the larger of the two, having a span of 70 ft. The underside of the centre of the arch is 18 ft. 6 in. above the finished road level, and the width between the piers 20 ft. The drawings on pages 11 and 12 show the detailed construction of this bridge.

All the concrete was mixed by hand in the proportion of 27 cu. ft. of ballast, 13½ cu. ft. of sand, and 5 cwts. of Portland cement.

The test load for the bridges was a 20-ton road roller, and six months



MOORTOWN ROAD BRIDGE, WIMBORNE, DORSET.

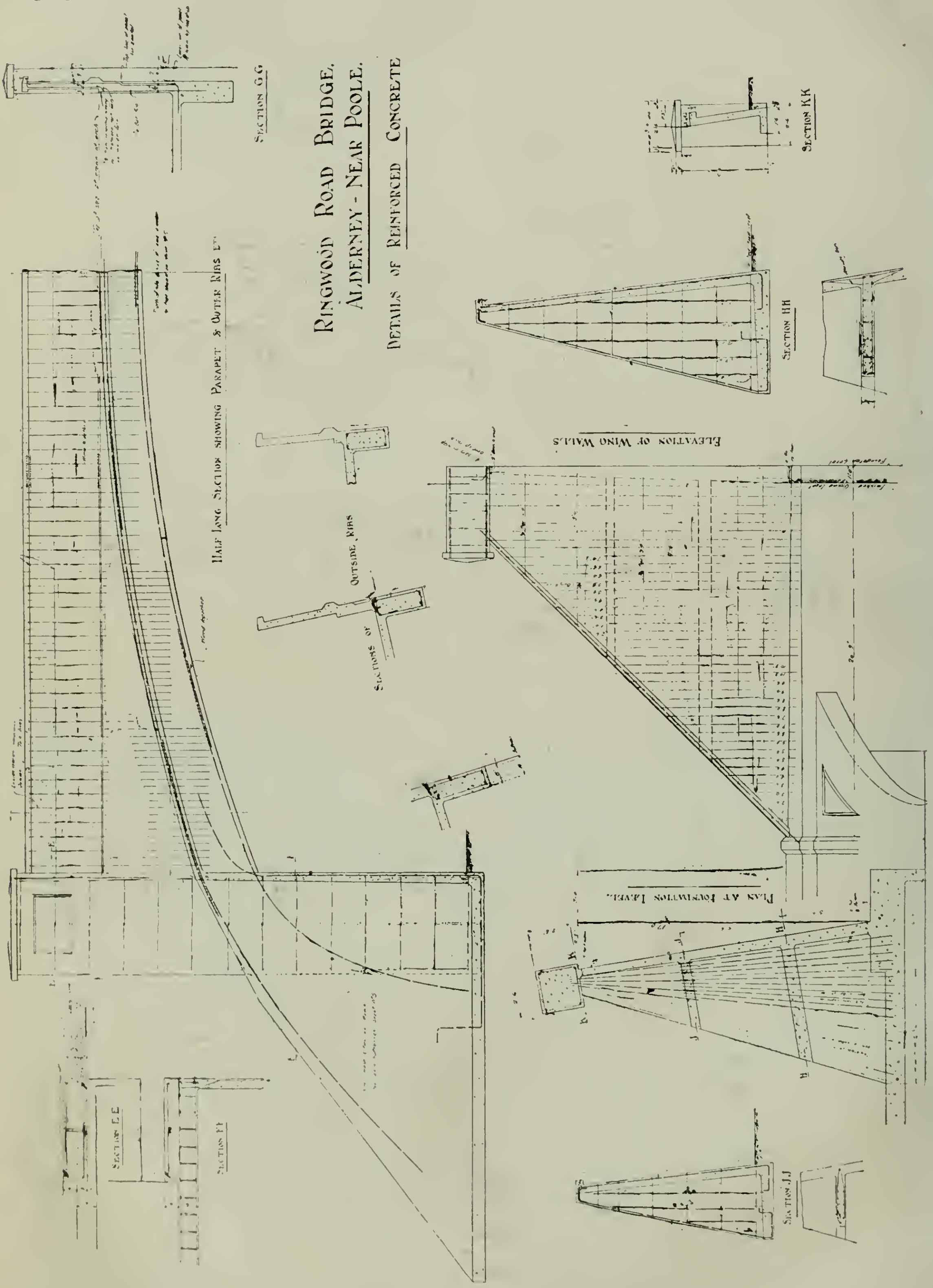


Details of the work.

Ringwood Road Bridge, Wimborne, Dorset.

after completion the test was carried out, the recorded deflection only amounted to a little over $\frac{1}{16}$ inch.

A view of the smaller bridge, that at Moortown Road, is given on page 10.



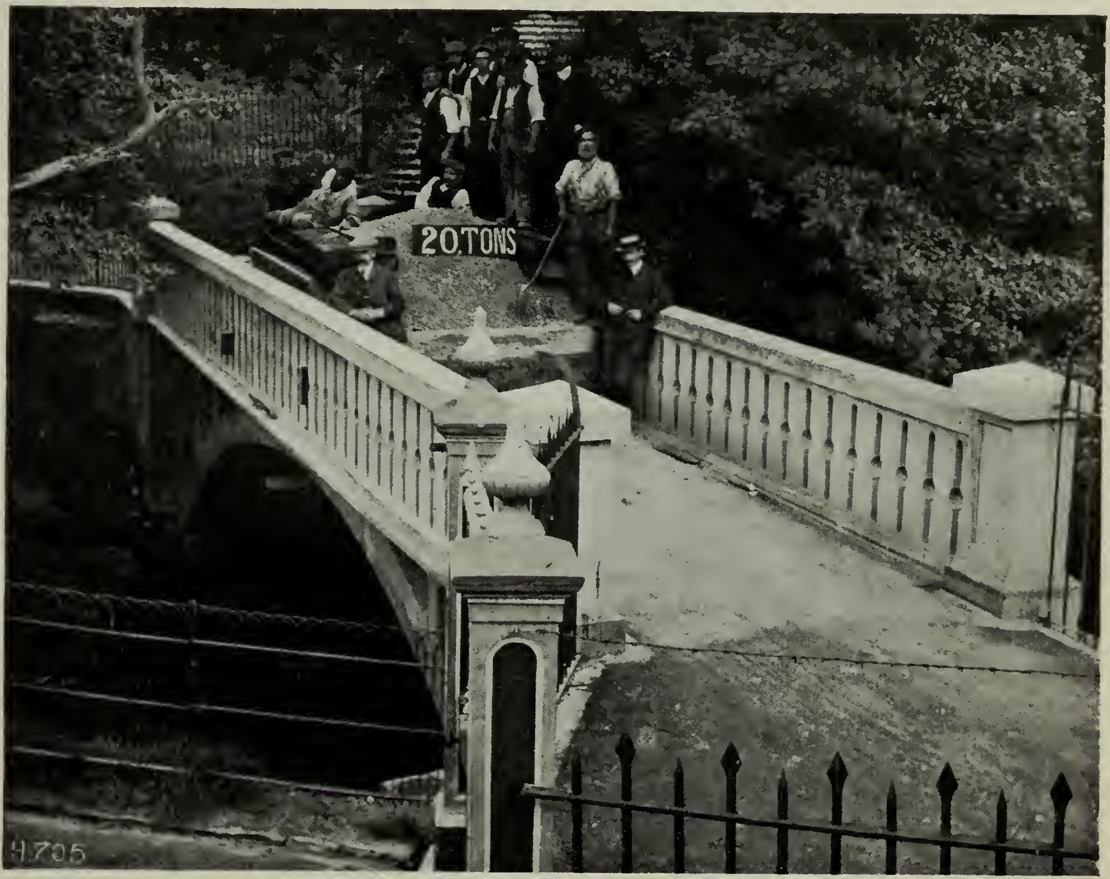
Details of the work.
Ringwood Road Bridge, Wimborne, Dorset.

These bridges were designed and executed by Messrs. The Cubitt Concrete Construction Co., of 260 Gray's Inn Road, W.C.

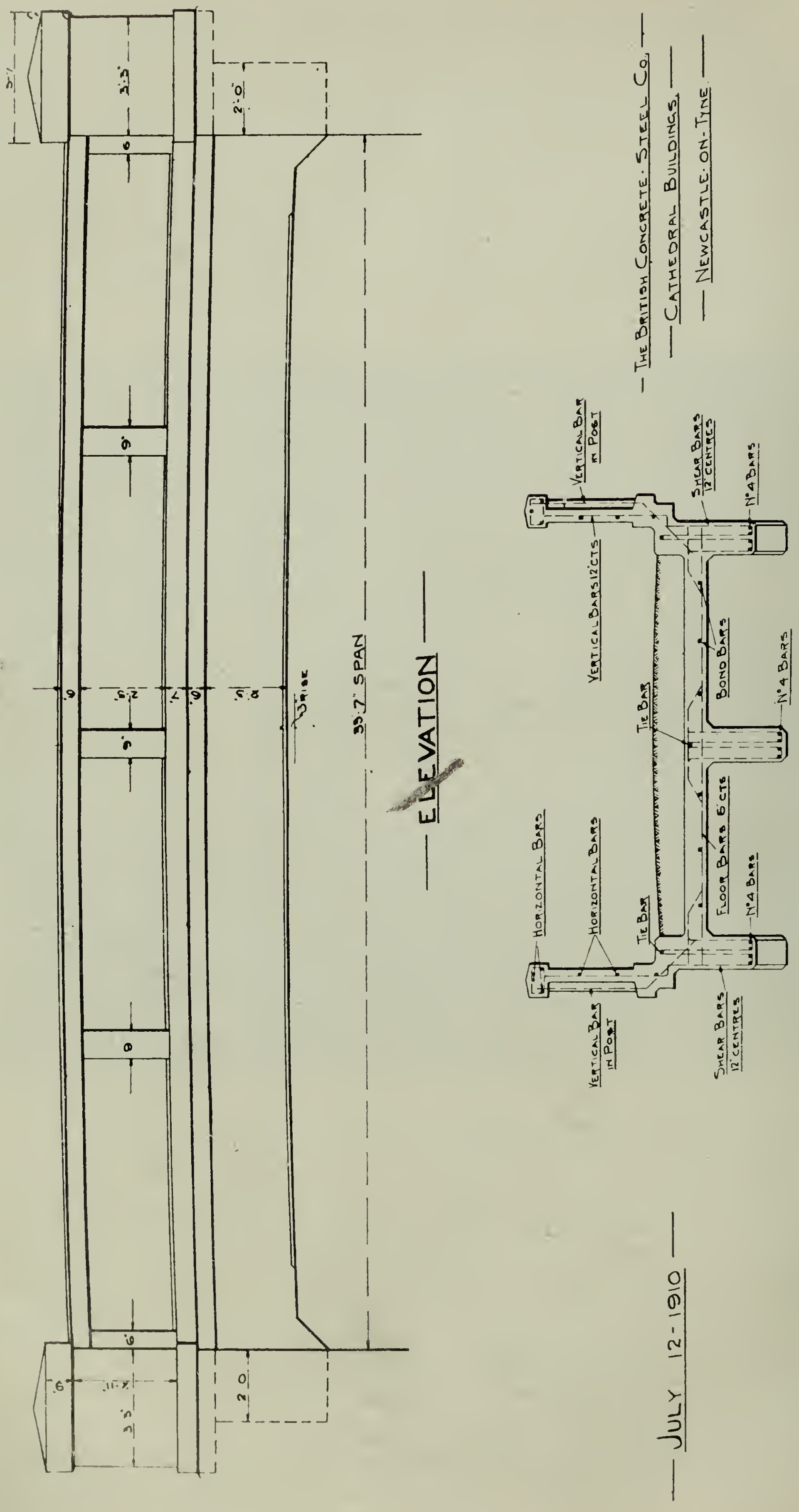
REINFORCED CONCRETE BRIDGES AT PENARTH.

Two bridges were recently erected at Penarth to replace two wooden structures, which had in fifteen years, although well looked after, rotted away. The new reinforced concrete bridges, a view of one of which is given on this page, are each designed to carry a superload of $1\frac{1}{2}$ cwt. per sq. ft. The smaller one has a span of 35 ft., and is 8 ft. wide between the handrails on the parapets. The larger bridge has a span of 44 ft., and is 8 ft. 6 in. wide between the handrails on the parapets. The rise of the arches is respectively 6 ft. and 8 ft.

The whole of the two structures, including foundation slabs, abutments, and parapets, is in reinforced concrete, on the Hennebique system. The parapets, as will be noticed from our illustration, are cantilevered out from the main arches, are of the open moulded type, and present a very handsome appearance. The handrail is especially reinforced to take heavy horizontal thrusts. The smaller bridge was tested with a concentrated load upon the main arch beams of 16 tons and the larger one in the same manner with 20 tons, the deflection in each case being only $\frac{1}{64}$ of an inch. The bridges were constructed by Mr. Gwilym L. Morgan, contractor, Pontypridd. The engineer for the bridges was Edgar I. Evans, Esq., A.M.Inst.C.E., Council Offices, Penarth.



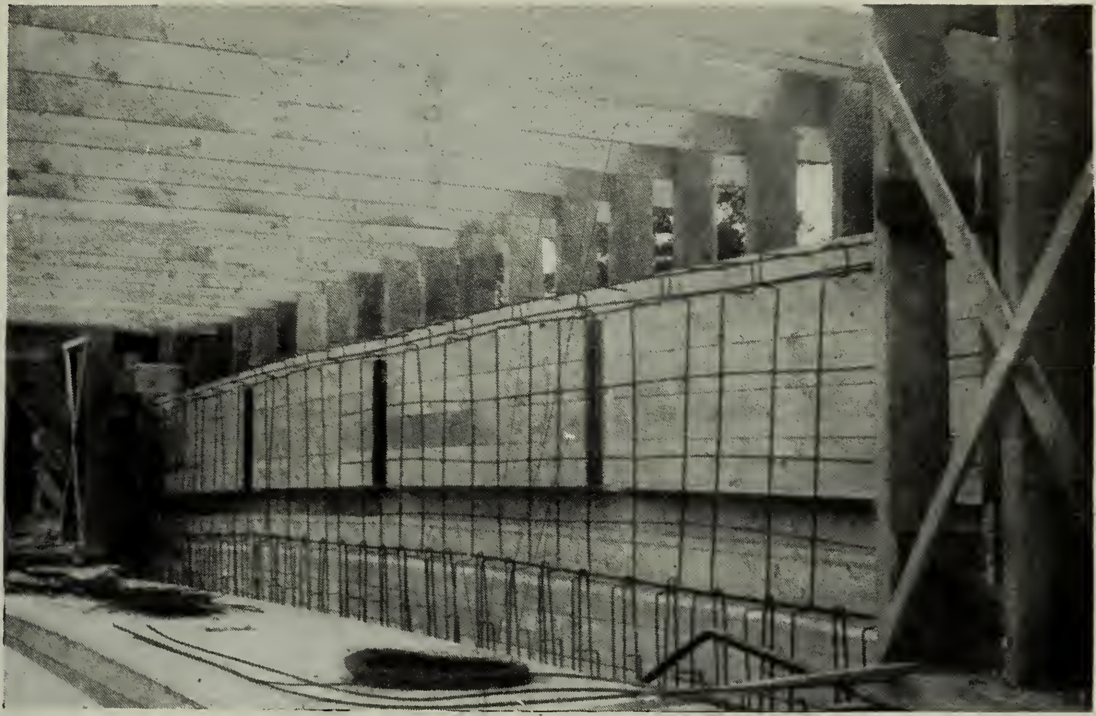
View taken during test.
Reinforced Concrete Bridge at Penarth.



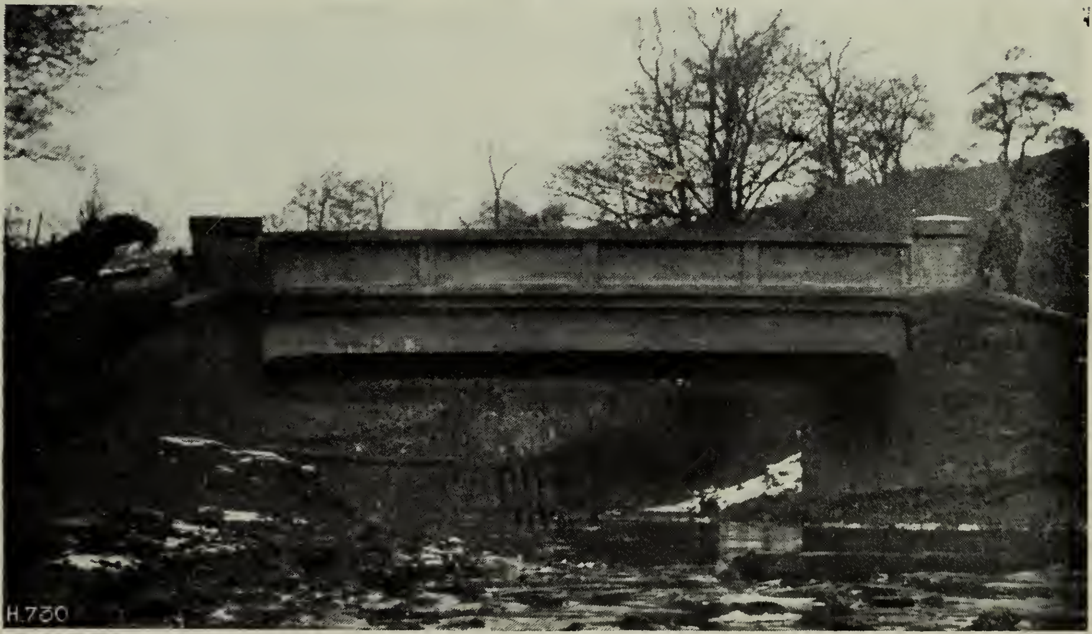
Section.
Reinforced Concrete Bridge at Longlee, Northumberland.

BRIDGE OVER THE WARKS BURN, LONGLEE, NORTHUMBERLAND.

THE accompanying illustrations show a bridge recently completed for the Bellingham Rural District Council to replace one which had become unsafe through the undermining of the foundations owing to the washing away of an adjacent dam.



Centering for road decking, main beams and parapets.



View of finished bridge.

REINFORCED CONCRETE BRIDGE AT LONGLEE, NORTHUMBERLAND.

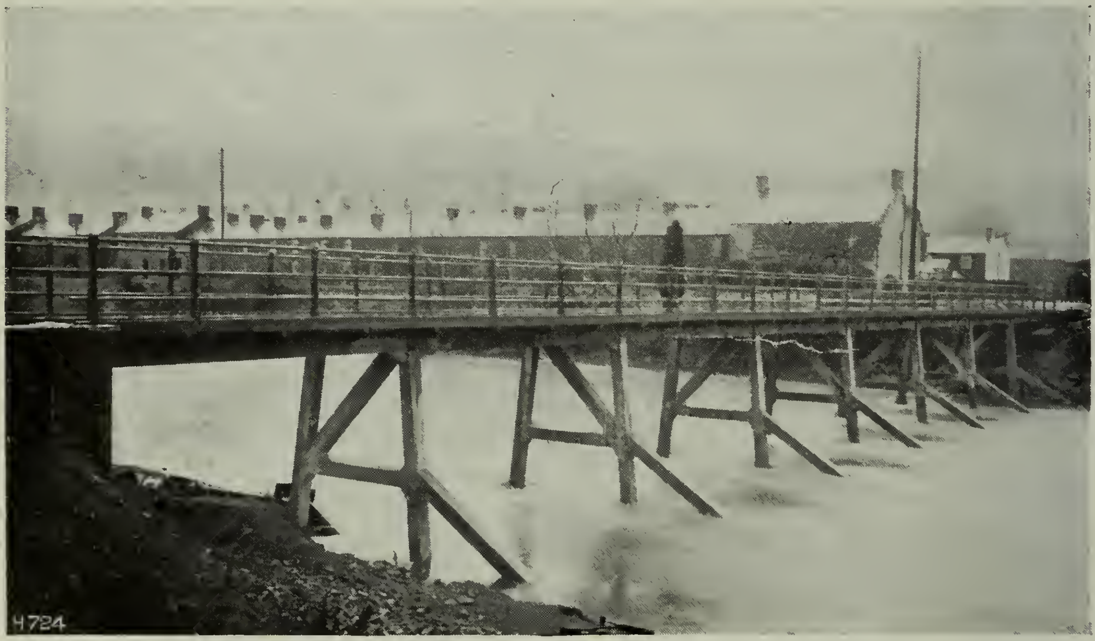
The new bridge has a span of 33 ft. 7 ins., and a width of 12 ft. between parapets.

The foundations for the abutments and wing walls consist of slabs of concrete 2 ft. 6 ins. thick carried down 6 ft. below the bed of the stream, and resting on blue clay of so hard a nature that it was necessary to blast it out with gelignite. The abutments and wing walls are solidly built of heavy masonry in cement mortar.

The road decking, parapets, and main beams are constructed of reinforced concrete. The decking is 7 ins. thick, and is supported by three longitudinal beams, each 33 ins. deep and 11 ins. wide. The parapets are 3 ft. 6 ins. high above the concrete curbs, the panels being 4 ins. thick, with a coping 11 ins. wide and 6 ins. deep. The bridge has a camber of 3 ins., and the outside main beams are haunched down into the masonry abutments.

The substantial centering used can be seen in the photos, and the surfaces did not require any touching up when the boarding was removed, and were only washed over with cement grout.

The engineers were the British Concrete Steel Co., of Cathedral Buildings, Newcastle-upon-Tyne, and the reinforcement used throughout consisted of square Indented Steel Bars.



Reinforced Concrete Bridge over the River Taff at Treforest.

BRIDGE OVER THE RIVER TAFF AT TREFOREST.

This bridge was constructed for the Pontypridd Urban District Council, on the Hennebique system of reinforced concrete, by Mr. E. H. Page, contractor, Cardiff. The bridge was designed by Mr. W. E. Lowe, the engineer to the above-named council.

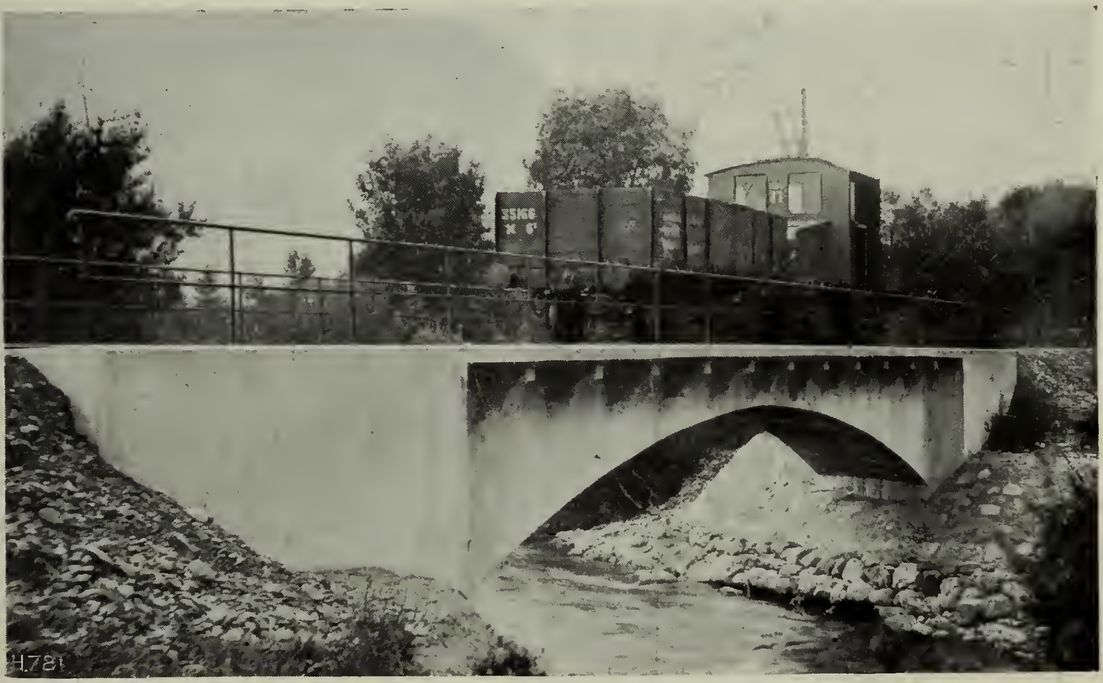
The uprights are carried on cast-iron pockets, which in their turn are carried on cast-iron columns let into the bed of the river. Great difficulty was experienced in getting the reinforced columns into these cast-iron pockets owing to the water which had to be dealt with in the river, which in time of flood will rise as much as 4 ft. in an hour.

There are eight spans of 25 ft. 6 ins. each, and the superstructure is carried on vertical braced columns 12 ins. by 12 ins. Each trestle has a strut, the foot of which is also carried in a cast-iron shoe, on the down side of the river. This is owing to the large volume of water which sweeps down this river at a great velocity. The bridge carries a cart track in the centre and a narrow footpath on either side. The handrailing is composed of steel tubes carried on reinforced concrete stancheons.

ARCH BRIDGE FOR THE SOC. ANOM. ELECTRO-METALLURGIQUE AT UGINE (SAVOY), FRANCE.

THE illustration on this page shows an arch bridge in reinforced concrete which has recently been erected on the Coignet system for the Société Anonyme Electro-metallurgique at Ugine (Savoy).

This skew bridge, which has a span of 20 metres (65 ft.) and a total length of 32 metres (105 ft.), with a width of about 5 metres (16 ft.), has been designed to support a single line of railway.



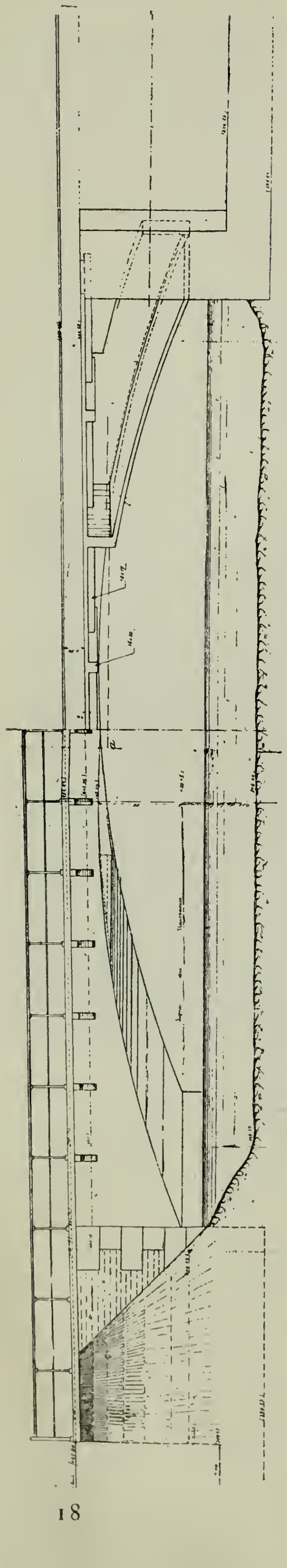
REINFORCED CONCRETE ARCH BRIDGE AT UGINE (SAVOY), FRANCE.

The rolling load specified for the calculations of the work was constituted by an electric train having a locomotive of 20 tons and three wagons weighing 25 tons each, with a wheel base of 3 metres (9 ft. 10 ins.). The work was also calculated for a superload of 400 kilos per square metre to be applied on both sides of the railway line.

The abutments in this bridge are also in reinforced concrete, and measure about 5 metres by 5 metres (16 ft.), with a height of approximately 4 metres (13 ft.).

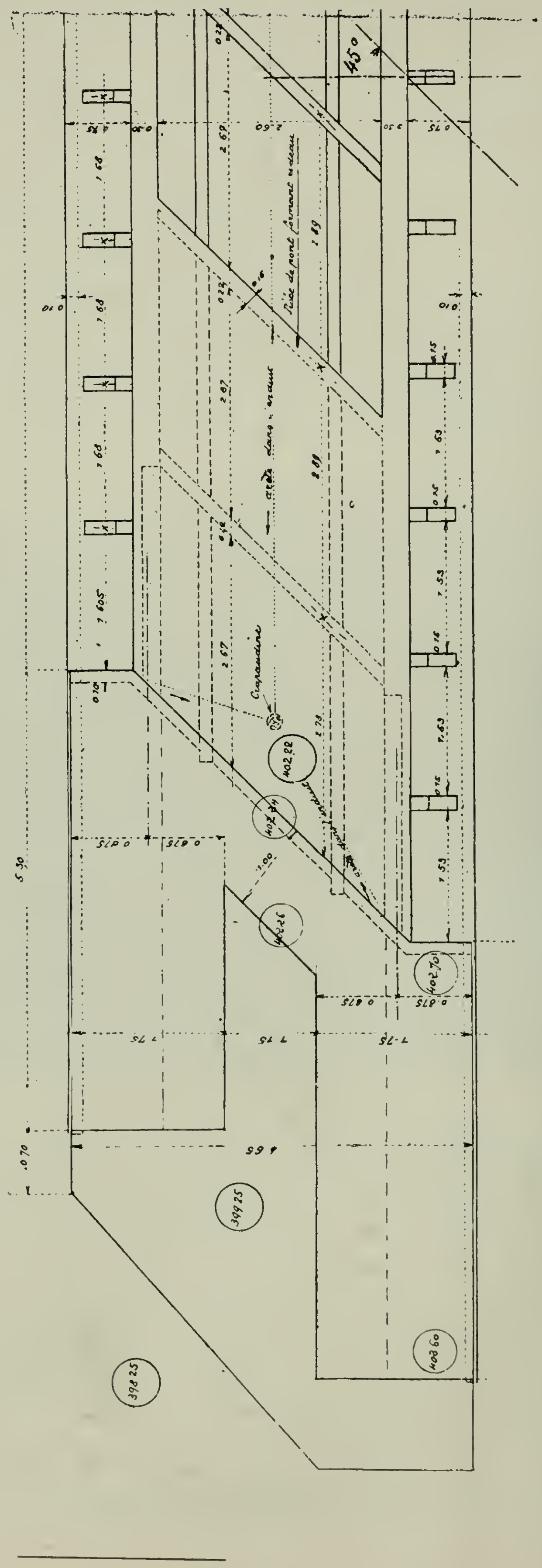
This bridge was built at an angle of no less than 45° on the skew, as shown in the accompanying drawing.

The work of erection was carried out by Messrs. Mazet & Limousin, licensees of the Coignet system of reinforced concrete.



Half longitudinal section.

Half elevation.



Half plan, from below.

Reinforced Concrete Arch Bridge at Ugine (Savoy), France.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete. These particulars have been prepared for this journal by Mr. A. W. Farnsworth, of Strand Chambers, Derby.—ED.

Reinforced Concrete Reservoirs.—*No.* 29,693/10. *E. W. Burbach. Accepted October* 6/10.—This is another endeavour to provide a reliable and practical liquid-tight joint between concrete slabs used in the erection of reservoirs, sea walls or similar works. In this system of construction the edges of the plates are made to loosely interlock, and when they are in position the interstices, *f*, are filled with liquid cement. It is stated that by this means a reliable joint can be obtained. It is also pointed out in the specification that it is a somewhat difficult matter to form an acid proof coating on the internal face of a tank already erected, but the use of ready-made slabs enables the application of the asphalte or whatever is used to be carried out under convenient conditions before the structure is built up.

Fig. 1.

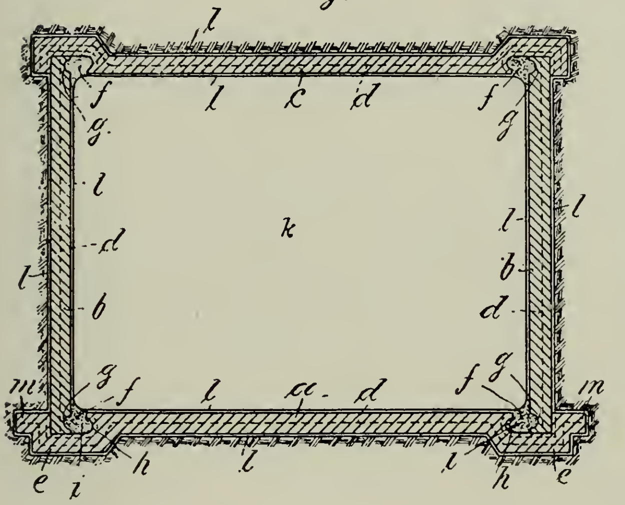


Fig. 2.

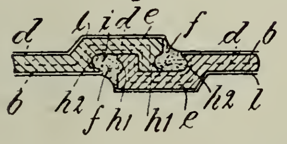
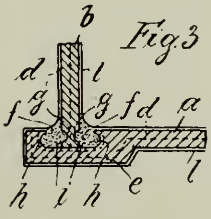
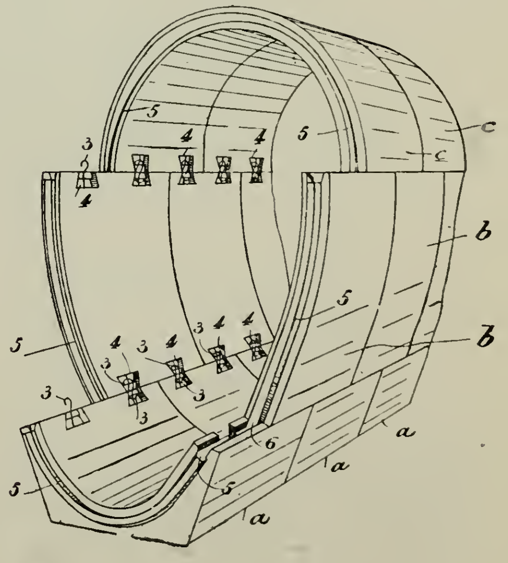


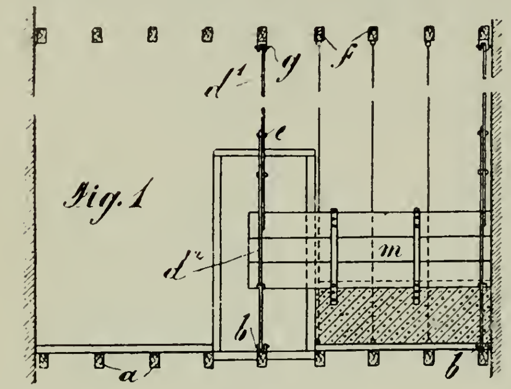
Fig. 3

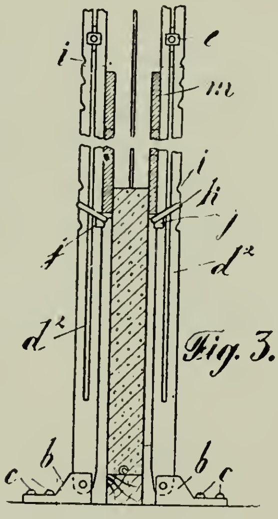


Details of Construction for Concrete Sewers.—*No.* 11,532/10. *G. Dujardin. Accepted September* 15/10.—The invention relates to an improvement in the construction of reinforced concrete sewers which are made up of slabs or panels previously moulded in the required shapes. The edges of the respective portions dovetail together, but the leading feature claimed for in the invention is the method of connecting the steel reinforcement which is embedded in the concrete prior to erection. In order to do this it is proposed that recesses should be made on the inside of the slabs at the points on the edges where the rods occur. The ends of the steel are thus exposed and may be bent over like hooks to engage each other; the surrounding space is then grouted so that the rods are finally completely embedded. It is claimed that the arrangement gives a perfect connection, and as there is no finishing work to do on the outside of the sewer the surrounding earth may be filled in directly the various parts of the ring are in position.



Shuttering for Concrete Walls.—*No.* 13,818/10. *P. Hedrich. Accepted September* 22/10.—If commercial success is to be obtained in the construction of reinforced concrete walls of average thickness it is necessary to considerably reduce the expense of the shuttering. Consequently many proposals have been made in order to lessen the cost of erection, and the invention is another effort along the same lines. In this instance it is suggested that the walls be made in sections, and movable shutters used, which may be placed in fresh positions as soon as the previous lot of concrete is set. The shutters, *m*, are mounted on metal standards, *e*, which are hinged at the bottom into bases temporarily fixed to the floor. Shoes to receive the tops of the standards are also fixed above. The distance apart of the standards and, therefore, the thickness of the wall may be varied by means of the adjustments made in the positions of the temporary attachments. When it is necessary to move the shutters upwards into their new position, in order to receive a fresh batch of concrete, the standards are released at the top and fall outwards, thus avoiding any injury to the face of the wall where it has just set. The position of the shutters when thus opened renders them readily accessible for cleaning and greasing. The shutters are held at the correct height on the standards by means of a simple locking arrangement.





A New Reinforcement Connection.—*No.* 29,152/09. *T. Potter. Accepted November* 3/10.—The invention relates to the difficulty encountered in the attachment of stirrups to the main members of the reinforcement, and is intended to provide a more convenient method than those previously used. In addition the connection may be adopted on steel bars of ordinary commercial sizes. Reference to the accompanying drawing shows that the respective bars are held together by means of links, *d*. The links, or collars, are threaded over the main members, *a* and *b*, until they are in the right positions to receive the end of the stirrups, and then, when correctly set, they are tightened by means of wedges driven inside them.

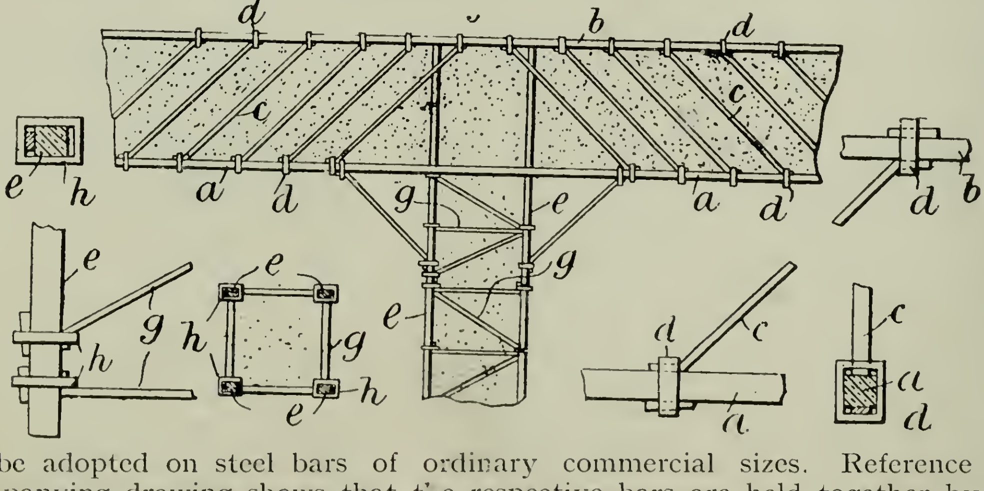


Fig. 3.

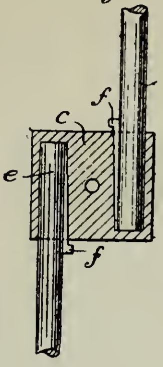


Fig. 4

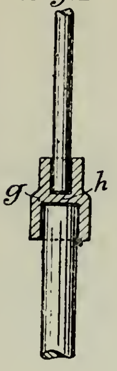
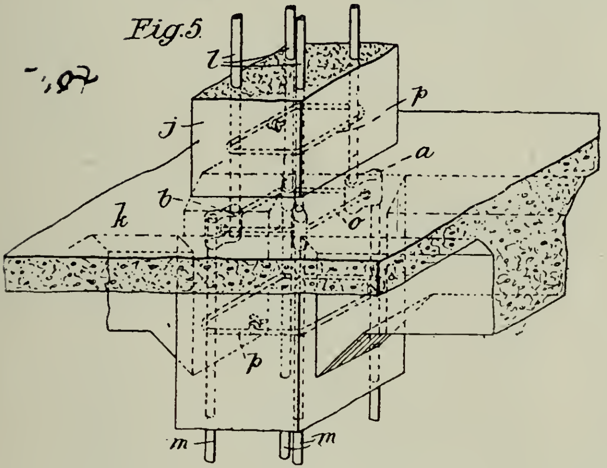


Fig. 5



A Practical Joint.—*No.* 30,312/09. *G. H. Gascoigne and the United Kingdom Fireproofing Company.*—*Accepted October* 13/10.—The object of the invention is to provide a simple joint for connecting the ends of vertical rods in the reinforcement. The case occurs frequently in the construction of reinforced concrete columns where usually the ends of the rods do not coincide, but are arranged as in *Fig.* 5. It is proposed to adopt a small casting consisting of two sockets to receive the rods, and connected by means of a thin web. The detail of the device is shown in *Fig.* 3, where it will be at once noticed that the bottoms of the sockets are solid and that the ends of the rods may be secured by means of keys or wedges, *f*. A hole pierced through the connecting web receives the horizontal tie, O, *Fig.* 5, which adds increased rigidity to the connection

Shafting Hangers Under Concrete Floors. — *No.* 10,747/10. *B. Bauer, Accepted September* 29/10.—The arrangement of fixing shafting hangers into reinforced concrete as introduced by the inventor is claimed to be a considerable improvement on previous methods. The leading feature consists in the adoption of a special U-shaped bracket which is placed across the top of the concrete beam; the two sides of the bracket extend downwards on each side of the beam to a short distance below the underside of the floor where they terminate in lugs, a^1. The lugs are slotted to receive the bolts, *c*, used to attach the hanger, *b*. It will be readily understood that the arrangement ensures a thorough distribution in the beam of the stresses transmitted from the shafting, and that the erection and removal of the hangers themselves may be easily effected.

Fig. 3

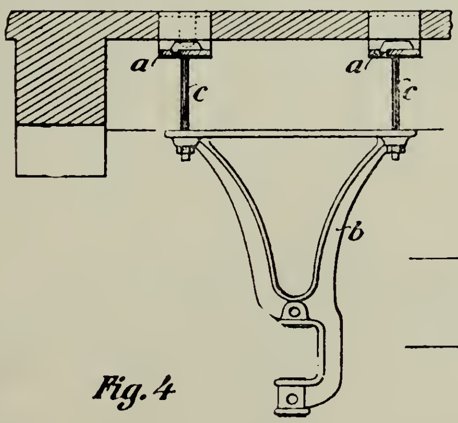


Fig. 4

Fig. 5

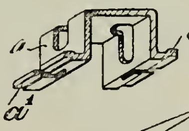
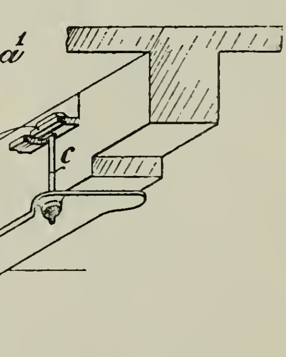
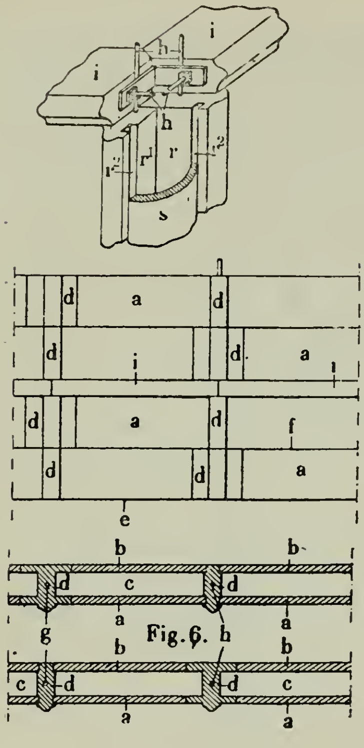


Fig. 6



Hollow Concrete Walls.—*No.* 18,177. *E. J. C. Bérard. Accepted August* 8/10.—The inventor introduces a new system of construction for reinforced concrete walls which are built up from standard slabs and bonding pieces specially designed for convenient erection. The walls, which are hollow, are first framed up in small vertical and horizontal members, *d* and *i*. Through these portions are threaded steel rods furnished with screwed ends, *h*, which may be tightened up by means of nuts when desired. The outer faces of the frame members are rebated to receive the slabs, *b*, which constitute the two wall faces. It will be readily seen that the slight projection of the frame offers some relief to the natural flatness of the wall surface, whilst the inventor claims that the system combines the minimum of material and labour with a considerable reduction in weight. Details of the mould required for the manufacture of the various parts are given in the specification.



Improvements in Hollow Concrete Floors.—*No.* 20,217/09. *W. Drexler. Accepted September* 5/10.—The invention relates to floors and ceilings constructed of hollow blocks with intermediate concrete filling. The inventor explains that in order to lessen the cost of manufacture the blocks are sometimes divided horizontally and built up in two portions. It is stated that with this system the filling is liable to pass through the joints into the interior of the blocks, and it is therefore suggested that the joints should be constructed on the groove and tongue principle in the manner indicated in *Fig.* 3. An attempt is also made to reduce the cost of centering by the adoption of the arrangement shown in *Fig.* 1, where it will be noticed that the number of vertical struts has been reduced by the adoption of bracing on the supporting wood beams.

Fig. 1.

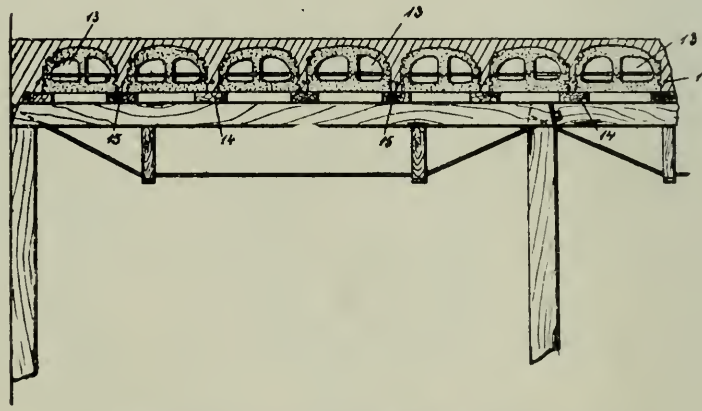
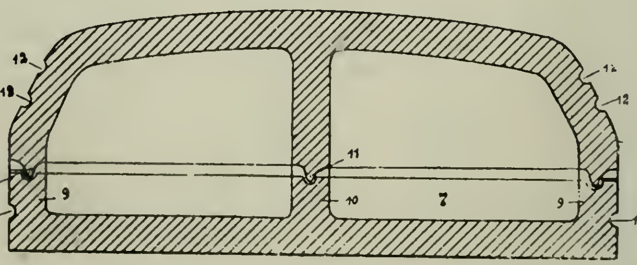


Fig. 3.



Economy in Erection.—*No.* 148/10. *Kraft and Kraft. Accepted November* 3/10.—In the specification the inventors describe a new method of erecting concrete floors, although the material employed is similar to that already used. The leading idea is to reduce the cost of centering for the concrete beams used to support the slabs. Hollow slabs, *Fig.* 1, are brought to the building ready-made and placed in position on the timber framing, *Fig.* 4. It will be noticed that when two rows of slabs are thus laid there is a continuous space between them. The space forms the mould for the reinforced concrete beam, *g*, without the use of any more timber. The concrete for the beam enters a short distance into the hollow spaces in the blocks, thus forming a key between the respective parts, *Fig.* 2.

Fig. 1.

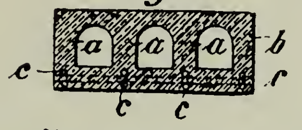


Fig. 2.

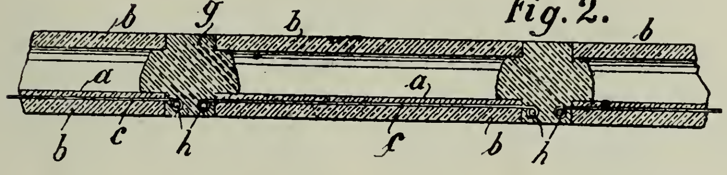
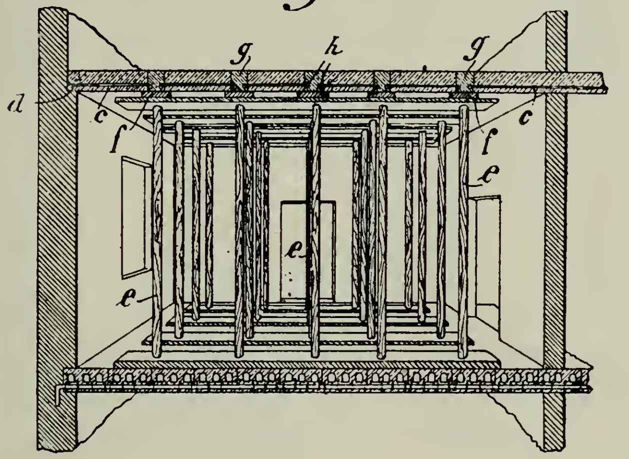


Fig. 4.



New Steel Details.—*No.* 27,645/10. *Pauchot. Accepted September* 22/10.—Here we have another system of reinforcement which is distinguished by the special means adopted to connect the ends of the steel in beams to that in the abutments. In this instance the reinforcement consists of flat bars, *Fig.* 1, or a flat and a T-bar, *Fig.* 8. At suitable points in the span the upper and lower members are bound together with clips; distance pieces may be introduced if required. At the abutments one of the flat bars is bent over the end of the other member and secured by bolts, *d*. It is explained that when the ends are finished in this manner it is possible to arrange for them to clip on to one of the bars in the supporting column or wall, *e*, thus ensuring some rigidity during erection. It is claimed that the reinforcement may be easily assembled on the site, and although the bars used are comparatively light, yet when put together they are stiff enough to support moderate loads until the concrete is in position.

Fig. 1

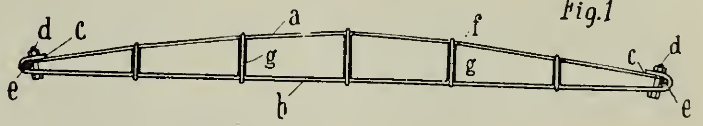
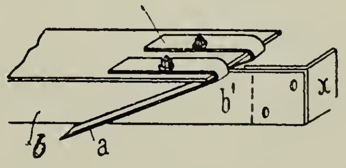
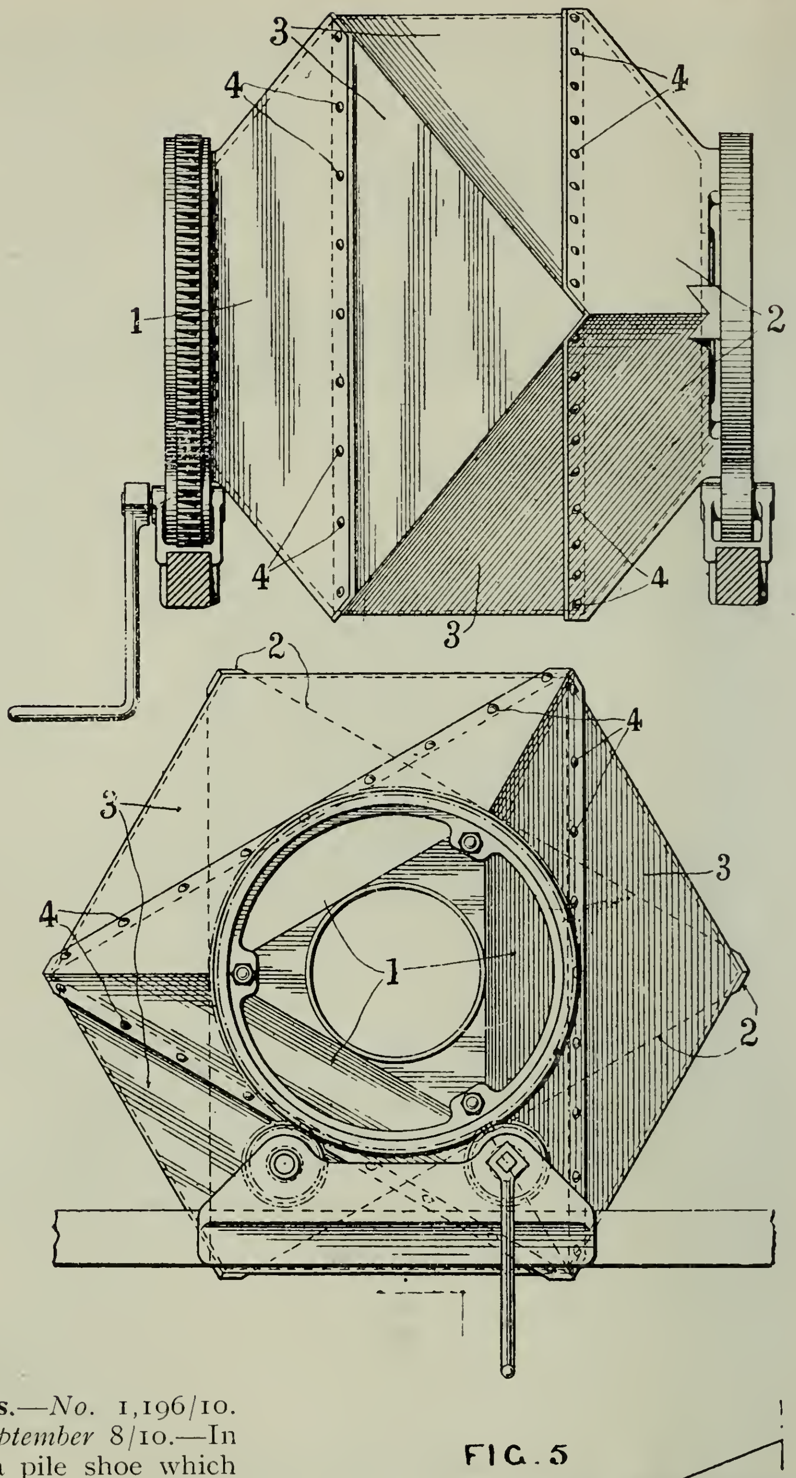


Fig. 8



An Improved Concrete Mixer.—*No.* 28,023/09. *S. & J. Whitaker. Accepted October* 27/10.—The mixer shown in the illustration has been designed so that the parts which receive most wear may be easily and cheaply renewed. The cube type of machine is adopted where the rotary drum, approximately a cube in shape, is mounted on two trunnions placed at diagonally opposite corners. The general design is familiar, but the inventors state the wear which takes place at the central portion of the drum involves its complete renewal from time to time, whether it is made of cast-iron or built up of rivetted steel plates. It is therefore suggested that the drum should be formed of two cast-iron cheeks, 1 and 2, joined together by a steel plate, 3, which is bolted to them, 4. The cast-iron sections which are attached to the bearings do not receive so much wear on account of their position and consequently may be retained in use for a long time without repair. The central portion, which may require renewal more frequently, is formed of a single steel plate which is bent in such a manner that the correct shape of the drum is preserved. The material is fed into the mixer through its open end as usual, and when required an outlet door may be provided.



A New Shoe for Piles.—*No.* 1,196/10. *W. D. Cay. Accepted September* 8/10.—In the illustration is shown a pile shoe which has been specially designed to facilitate the attachment of the lower ends of the steel reinforcement. The shoe is constructed in two principal parts—a metal point, *P*, and a barrel, *W*. The ends of the reinforcement, *R*, are rivetted, wired, or otherwise secured to the barrel, thus ensuring a sound job. The metal point may be fixed into the end of the barrel in any convenient manner. Several variations in the method of construction are described in the specification.

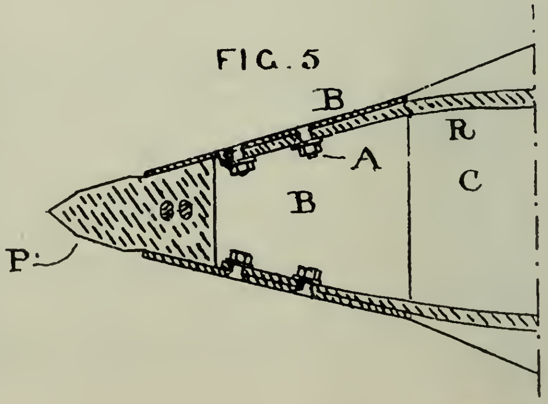
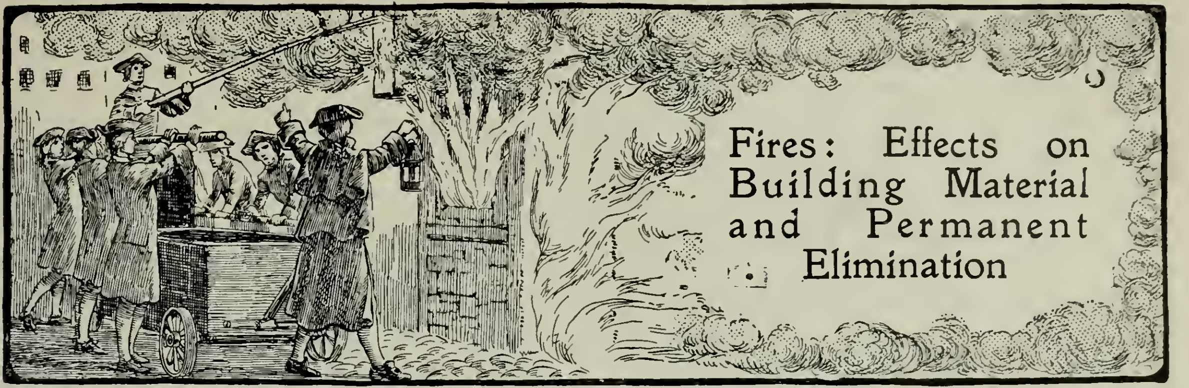


FIG. 5



Fires: Effects on Building Material and Permanent Elimination

By FRANK B. GILBRETH, New York.

A paper read some little time back by Mr. Frank Gilbreth, of New York, on the advantages of concrete from a fire point of view, continues to be accorded attention, and we therefore publish a lengthy extract from the paper as issued by the American Society of Mechanical Engineers. The arguments put forward so tersely by the author merit careful consideration in Great Britain, as also in our overseas possessions.—ED.

GENERALLY.

In this age of " conservation " it is amazing that so little has been done to prevent destruction by fire, and to apply the lessons that every great fire teaches us. The interest of the entire public in fireproof construction flares up with a great fire, but flickers out before the building permits for new structures are granted. The average owner when rebuilding even finds fault with the authorities whose duty it is to enforce the inadequate existing ordinances relating to non-combustible construction and to " fire-stopping " in combustible buildings.

There must probably be more big fires among buildings now built, but there is no sane excuse for any such loss in the buildings to be erected in the future. Within the last six years there have been wonderful opportunities for studying great fires here in our own country. It has been possible to observe the destruction that occurred, to discover why it occurred, and to determine exactly what must be done if repetition of such destruction is to be prevented in the future.

It has long been realised that, with the wood supply of the world constantly diminishing, wood was bound to become too expensive to use as a building material. To-day, concrete structures can be erected at no greater first cost than wooden ones ; with an added element of safety to those who use the buildings which cannot easily be overestimated.

COST OF CONCRETE CONSTRUCTION.

In order to hold the place it claims—that of the cheapest and best fireproof construction material—concrete must be able to show itself cheapest in first cost, as well as cheapest in the long run.

Concrete materials are obtainable everywhere : stone, ledges, gravel, sand, burnt ballast, slag, brick refuse, terra cotta chips, stone-cutters' refuse and cinders, are all good aggregates for concrete.

As far as the cost of the labour of putting the material in place is concerned, much has been done toward reducing that to a minimum. With metal forms and certified concrete, concrete construction is cheaper to-day than that with brick, hollow terra cotta tile or any other material.

Charles T. Main, a member of the Society, has recently published the most valuable contribution regarding cost data of brick and wood mill construction. Mr. Main is a leading authority on this subject, and his data are conceded to be correct.

Mills have been built entirely of concrete, in all parts of the country, in less time than it is possible to build them of brick and wood, and for less money than the square foot and cubic foot prices collected by Mr. Main. A few years ago this statement would not have been true. To-day, with the aid of new designs, new methods, new forms, scientific grading and proportioning, it is a fact that cannot be disputed, but one, nevertheless, not generally known.

The development of the entire concrete building and of the parts of the concrete building have been slow, because it has taken a long time to learn to *think* in concrete. Each student brought his stock of experiences from another field to bear on the problem, but the problem was so new that few could understand it in all its aspects. The engineer, who knew how to design the strength, knew little about artistic features. The architect, who alone could give beauty to the building, was not an expert in the methods that make low costs. Progress was made more difficult by the fact that so few of the structural features and construction methods were standardised.

The contractor, having analysed his costs, saw that the forms were the largest single item in the cost of the concrete. This fact had its effect on the design of the concrete building, in the trend toward straightway repetition form work and flat-slab ceilings, with as little beam and girder work as possible. A further benefit was in the fewer corners for fire to attack, or for interruption of the action of sprinklers, saving also in the cost of the sprinkler system.

After the flat-slab ribless type of ceiling, with its low cost of forms, came standardisation of the units of forms for walls and columns. With the use of these metal form-units a new problem faced us—namely, slight modification of design to agree with the cheapest labour requirements of the metal forms. The influence was also felt of the fire protection design thoroughly worked out and standardised by Charles L. Norton, professor of heat measurements at the Massachusetts Institute of Technology, and engineer in charge of the engineering experiment station of the Factory Mutual Fire Insurance Companies. Mr. Norton's recommended practice, which is now universally accepted, is so simple and apparently so obvious that we sometimes forget to give him the credit for his work.

The importance of the forms, from the standpoint of economy, in being able to build fireproof buildings for the price of brick and wooden mill construction, is clearly shown by the fact that Charles D. Watson, of Syracuse, New York, on account of the reduction in the number and expense of forms, has been able to build a number of buildings from separately cast members, and reduce the costs below anything ever cast *in situ* in wooden forms.

USE OF METAL FORMS.

We come now to the latest developments, the metal form-units that have been perfected, densifiers for compacting the concrete, mechanical conveyors for displacing the wheel-barrow and hand tamping, and the concrete-producing factory, centrally located. These things have all arrived. Metal moulds have reduced the price of concrete to that of wooden construction.

For the greatest saving in the cost per cubic foot of the completed building, the methods of construction, as well as the designs, must be standardised. This is rapidly being done. For example, the metal forms are set up and concrete is hauled in large quantities from a centrally located factory and poured at once for the entire story of a building. This does away with the joints between the work of two different days, and permits of figuring the tensile strength of the concrete in design calculation, with a great consequent saving of reinforcement. Such calculations cannot be safely figured unless the whole story is poured at once.

BEARING ON ULTIMATE COST OF HEALTH CONSIDERATIONS.

Figuring the cost of furring, lathing, plastering, interest, fixed charges, heating, and repairs, concrete is certainly cheaper than wood. If you also figure health concrete is *very much* cheaper. A concrete building is cooler in summer and warmer in winter than any other kind. It can be cleaned out with a hose. It can be easily, quickly and thoroughly fumigated, room by room, or all at once. It is drier than any other, provided it is built with self-ventilating air spaces in all of the exterior walls. A concrete building is vermin-proof, and should germs or vermin get in the building, it may be easily rid of them.

ADVANTAGE OF CONCRETE CONSTRUCTION IN ELIMINATION OF FIRE LOSS.

It may seem that we have wandered from our subject of fires and their permanent elimination, but it was necessary to show that concrete is thus, from *every* standpoint, cheaper than wood, its only rival for low cost. Concrete construction is the best form for the elimination of fires, because it affords :

(*a*) Least cause for fires.
(*b*) Least amount of damage to structural parts by fire.
(*c*) Least amount of damage to structural parts by water.
(*d*) Least amount of damage to contents of building by water.
(*e*) Least quantity of combustible structural materials in a room.
(*f*) Least speed of combustion of the contents of a room.
(*g*) No concealed fires ; all fires are in plain sight.
(*h*) Least spread of fire to adjoining parts of the same story.
(*i*) Least spread of fire to stories above.
(*j*) Least spread of fire to next buildings.

The causes of fires this paper will not discuss. The amount of damage done by a fire in a concrete building depends upon circumstances perfectly within our control and predeterminable. With concrete made of properly selected fire-resisting materials, practically no damage is done, except by prolonged high temperature. The results of recent tests by Prof. Ira H. Woolson and his assistant, J. S. Macgregor, prove conclusively that a concrete building properly designed, with as few projecting corners as possible, will withstand long periods of the hottest hardwood fires, with no resulting damage that cannot be thoroughly repaired with mortar and a plasterer's trowel. These tests were on full-sized rooms with walls of concrete made of different kinds of material.

Concrete for walls can be poured in metal moulds with sufficient accuracy to permit of painting or wall-papering without further plastering or smoothing. This means that the best of this fire-resisting material is brought to the very surface of the wall where the flames strike. With metal moulds, all corners can be made rounded as cheaply as square, or metal corner beads may, if desired, be inserted and retained in the moulds. Now, if a fire does occur in a building made of concrete cast in smooth metal forms, the damage is less than in any other type of building, and the danger of spreading is less.

A concrete building can be damaged by water less than any other form of construction. To begin with, water does not injure concrete ; in fact, it improves its quality. There is no wood to swell, and afterwards to shrink and crack the plastering. Even the paint best suited to be used on concrete lends itself particularly well to washing down with water. There are no hollow spaces that the water can flow through, damaging the contents below. A concrete building is water-tight from floor to ceiling, and small quantities of water can be easily handled through small scuppers, either into the air space of the vaulted wall, or through the wall to the outside. The fire is never hidden by the construction ; consequently no unnecessary streams of water are flooded into the building.

In a concrete structure there need be little or no combustible material. Let us take, for example, the dwelling house, for it is the most difficult to make both cheap and fire-proof. In a concrete residence there is little trim that cannot be made better and cheaper of Portland cement than of wood. The chair rails and picture moulding can be made of concrete. The trim around the windows and doors can be moulded in metal moulds as cheaply as straight members. Even the wire mouldings can be done away with, and the conduits buried in the concrete partitions, walls, ceilings and floors. Baseboards should be made of concrete or else omitted entirely—as they serve no useful purpose in a concrete building, except in following wooden precedents. Windows may have cement sashes, with wired glass, and self-closing shutters, or self-dropping shutters of rolled-up metal or asbestos. Metal furniture may be used. The paint and varnish used on buildings and furniture should be selected carefully, as these are great factors in determining the temperature at which a fire will start and the speed with which it will spread. There is also a great difference in the paints and varnish used for painting concrete.

The flooring need not be of wood. There are many first-class non-combustible materials beside Portland cement that will fill every good requirement of wood and still be fireproof. There are also parquetry floorings, made of slow-burning wood, and much thinner than the old-fashioned hardwood floor, which make the best flooring in case wooden floors are desired. In a concrete residence there is no excuse for wooden under-flooring, nor for wooden screeds.

The best form of construction for the elimination of fires is one that keeps the fire in plain sight, once it is started. One of the greatest obstacles in fighting fire in wood construction is the difficulty of locating a fire after it is known to exist. Every second of time lost gives it accelerated fury. Holes cut through the walls, floors and ceilings to locate a fire oftentimes only furnish more draughts to feed the flames.

With hollow concrete blocks, or monolithic cast-in-place walls and partitions there are no chances for the fire to be concealed. There is no cause for cutting into the partitions, floors, or ceilings. There is no damage to the structure from cutting, no injury from water. With such a building, if a fire does start, it starts in plain sight, remains in plain sight at all times, and can be attacked instantly before it has spread, and the water damage will be practically nothing. Fires in plain sight are usually extinguished before the arrival of the fire department.

SHEAR MEMBERS IN REINFORCED CONCRETE BEAMS.

By MAURICE BÉHAR,
Engineer of the Ecole Nationale des Ponts et Chaussées, France.

The following article by Mr. Maurice Béhar, who is prominently associated with the Coignet system of reinforced concrete, should claim attention.—ED.

THE exact distribution of shearing efforts in reinforced concrete beams is a question which is not always clearly understood.

In this article the writer will endeavour to explain the action of these particular efforts, and the most rational method of counteracting them.

Let us consider, for instance, these efforts in a beam uniformly loaded. We find that the external efforts have a tendency to produce a certain amount of bending, the effect of which is to cause compression in the concrete situated above the neutral axis, and tension in the steel and concrete situated in the lower part of the beam. There is at the same time a tendency of the various elements forming the mass of the concrete to shear in a vertical direction. This tendency is greater at the points of support and gradually decreases towards the centre of the beam, where it is nil. These efforts are known as vertical shear, see *Fig.* 1.

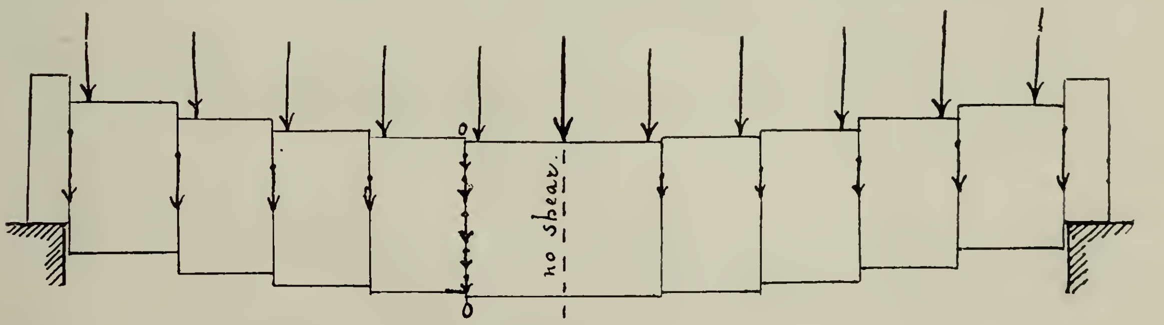


FIG. 1.

The efforts of bending and vertical shear are not, however, the only efforts which we have to consider in a beam. There are other efforts which have a tendency to cause a longitudinal slipping or shearing of the various elements of the mass of concrete, in the manner illustrated in *Fig.* 2. In other words, if we consider a beam composed of a certain number of layers of homogeneous material, the external efforts would produce longitudinal slipping or shearing of the elements of the mass in opposite directions from the centre of the beam.

It will be noticed that whereas the slipping is absolutely nil in the centre of the beam, it gradually increases towards the supports, at which points it attains its maximum.

If we consider the various points situated in a sectional plane, the efforts of longitudinal shear are greater at the centre or neutral axis and gradually lesser towards the upper and lower faces of this beam, where the slipping becomes nil.

It has been proved in theory that these longitudinal efforts of slipping are equal in magnitude to those of vertical shear in any particular point of the beam.

It is obvious, therefore, that it is necessary, in a reinforced concrete beam, not only to counteract the efforts of bending, but also to provide for adequate reinforcement to counteract vertical and horizontal shear.

The first specialist engineers provided steel reinforcement placed in a normal direction to the planes of action of the forces. In other words, the efforts of vertical shear in any vertical plane of a reinforced concrete beam were counteracted by the horizontal main bars, and the horizontal efforts of longitudinal shear were counteracted by vertical stirrups in a normal direction to the various planes of action on the said efforts.

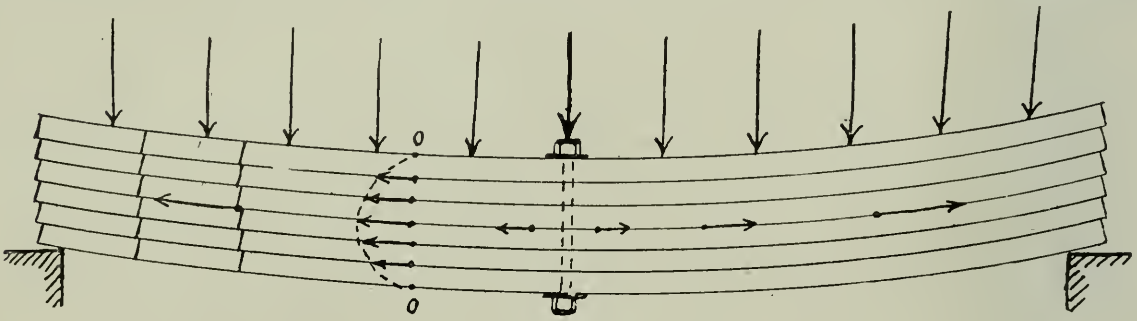


Fig. 2.

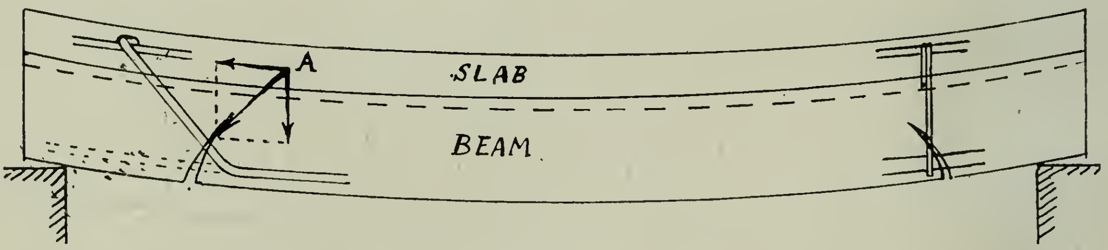


Fig. 3.

Later on, however, nearly all the specialists provided, as an alternative, a special arrangement of the shear members to counteract the resultant effort produced by vertical and longitudinal shear instead of counteracting these two efforts individually, as mentioned above.

By this new method of counteracting this resultant force, the shear members are placed in a normal direction to the plane of action of the resultants, namely—at an angle of 45° with the horizontal.

If we consider *Fig.* 3, and if we take any particular point in a beam, not contained in the vertical plane at the centre of the beam (where these efforts of vertical and horizontal shear are nil), we have two efforts starting from the point A. One of these efforts is acting in a vertical direction, and the other in a horizontal direction. As stated above, it has been demonstrated in theory that these two efforts are always equal. The resultant force acting in a downward direction has a tendency to shear the concrete, so that the bars, which are placed in a normal direction to this force, have a tendency to be sheared through.

We must not forget, however, that at the same time as this action takes place the beam itself is subjected to bending, which means that the underside of the beam has a tendency to become extended. It is obvious that if such a beam is stressed to its ultimate resistance in shear, the concrete will fail in the direction of the resultant force, and the fissure will have a tendency to open in the shape of a wedge.

The shear members, which are placed in a normal direction to the plane of the fissure, will have a tendency to be drawn out of the mass of concrete which is nearest the support. It is necessary, therefore, that this end of the shear members should have a mechanical anchorage in order to counteract the tendency of these bars to be pulled out of the concrete. It is for this reason that certain specialists think it advisable to hook the end of these shear members over a longitudinal top bar instead of relying entirely on the adhesion of the concrete to resist these efforts of diagonal tension.

It is obvious that this has the effect of considerably strengthening the beam in shear and preventing, at the same time, a sudden failure without warning immediately after any shear cracks have begun to develop in the concrete.

For this reason also the ends of the vertical stirrups should be bent over a top bar, or otherwise mechanically anchored to the upper portion of the beam.

It will be noticed that the shearing efforts reach their maximum at the neutral axis; the practice of leaving the ends of the stirrups of shear members free in the middle portion of the beam cannot therefore be recommended.

The writer is of opinion that in certain cases where architects or engineers have to decide on the choice of several schemes, prepared according to the views of different specialists, sufficient attention is not given to the methods of anchorage of the top portion of the shear members.

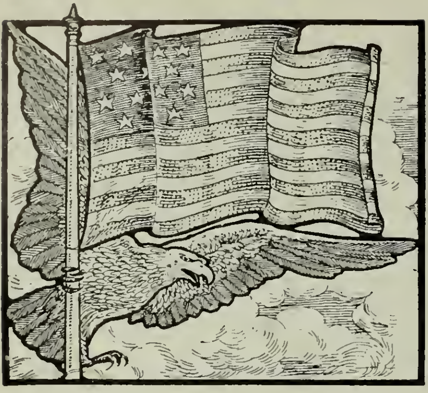
The common practice amongst specialist designers is to calculate the sectional area of the shear members by allowing only 12,000 or 13,000 lbs. per sq. in. for the resistance of the steel.

The fact that the shear members are working in tension, as soon as the first shear cracks begin to develop, is not sufficient reason for considering this steel as being in tension, and calculating its resistance by applying the tensional stresses of 16,000 or 17,000 lbs. per sq. in.

Architects or engineers who have to select some particular system should thoroughly investigate this question with a view of ascertaining if the designer has calculated his shear members with the value which is usually attributed to steel working in shear—namely, 12,000 or 13,000 lbs., or whether he has attributed to these the higher values of 16,000 to 17,000 lbs., assuming these shear members to be in tension.

It has been demonstrated by experiment that in beams loaded to destruction the first signs of failure are usually shear cracks.

It is therefore very important that these particular efforts and the best methods of counteracting them should be properly understood.



RECENT EXAMPLES OF CONCRETE AND REINFORCED CONCRETE WORK IN U.S.A.

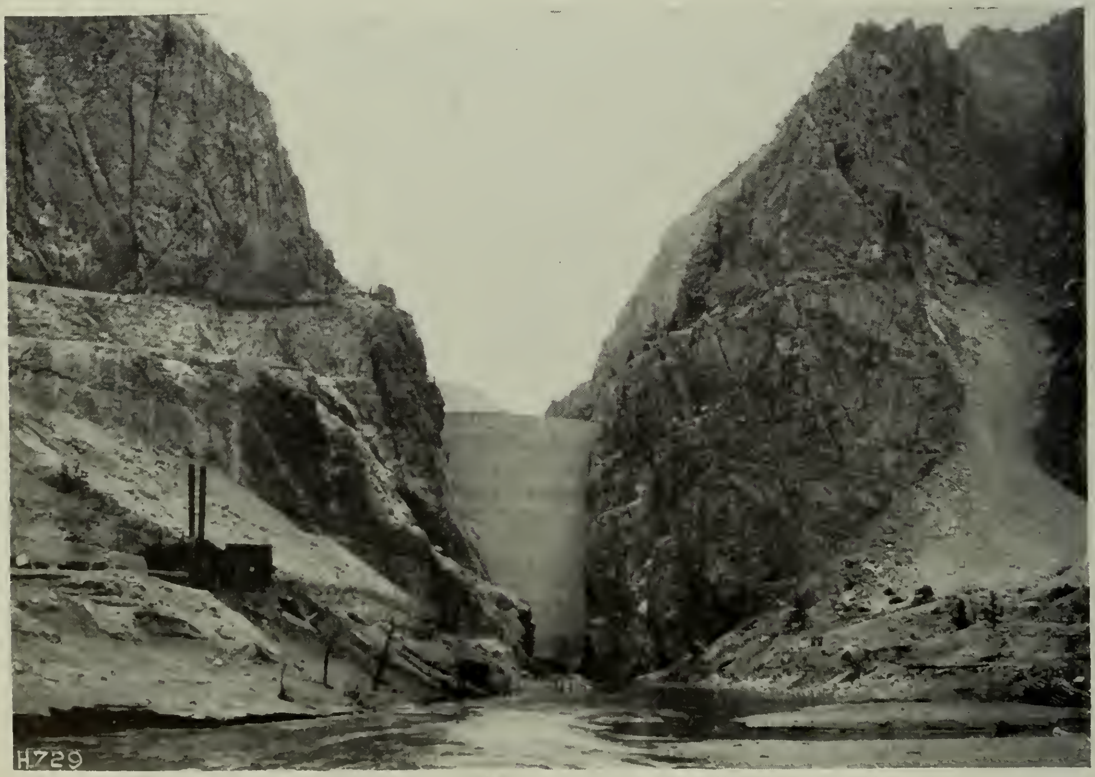
We are publishing in this article a few examples of recent work in concrete and reinforced concrete in the United States, where the use of these materials is increasing in a remarkable manner. We shall publish further examples from time to time.—ED.

THE SHOSHONE DAM, WYOMING, U.S.A.

Highest Concrete Dam Completed.

THE Shoshone dam in Wyoming, U.S.A., which is supposed to be the highest in the world, is a structure built entirely of concrete. It has recently been completed by the United States reclamation service.

This dam rises 328 ft. above bed rock, between the granite walls of the canyon of the Shoshone river, and holds the water in a reservoir with a surface area of ten square miles for the purpose of irrigating about 132,000 acres of land. The erection of this monolith of 70,000 cu. yds. of concrete at the bottom of a canyon, with nearly vertical walls 1,400 ft. high, was an engineering work of great interest. A feature

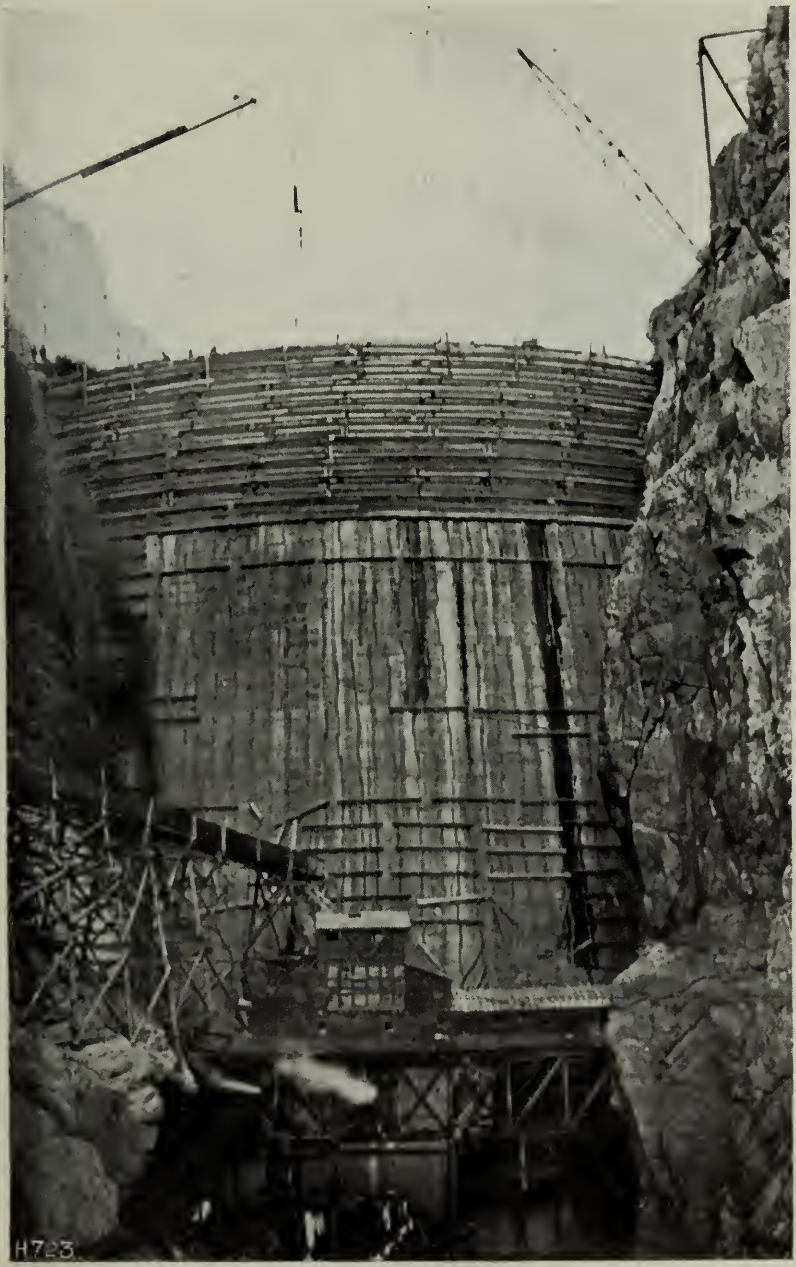


Upstream face of dam.
SHOSHONE DAM, WYOMING, U.S.A.

of the concrete work was the fact that all stone and sand was crushed and pulverised granite obtained from the canyon walls.

The dam is located below the junction of the north and south forks of the Shoshone river, about eight miles west of Cody, Wyo. At this point the sides of the canyon converge into a narrow gorge. At the site of the dam the canyon is only 70 ft. wide at the stream bed and 180 ft. wide at the top of the dam, which is about 250 ft. above the stream bed. The solid rock on which the dam rests is 85 ft. below the stream. By converting the canyon above the dam into a reservoir, the entire discharge of the river is made available for irrigation.

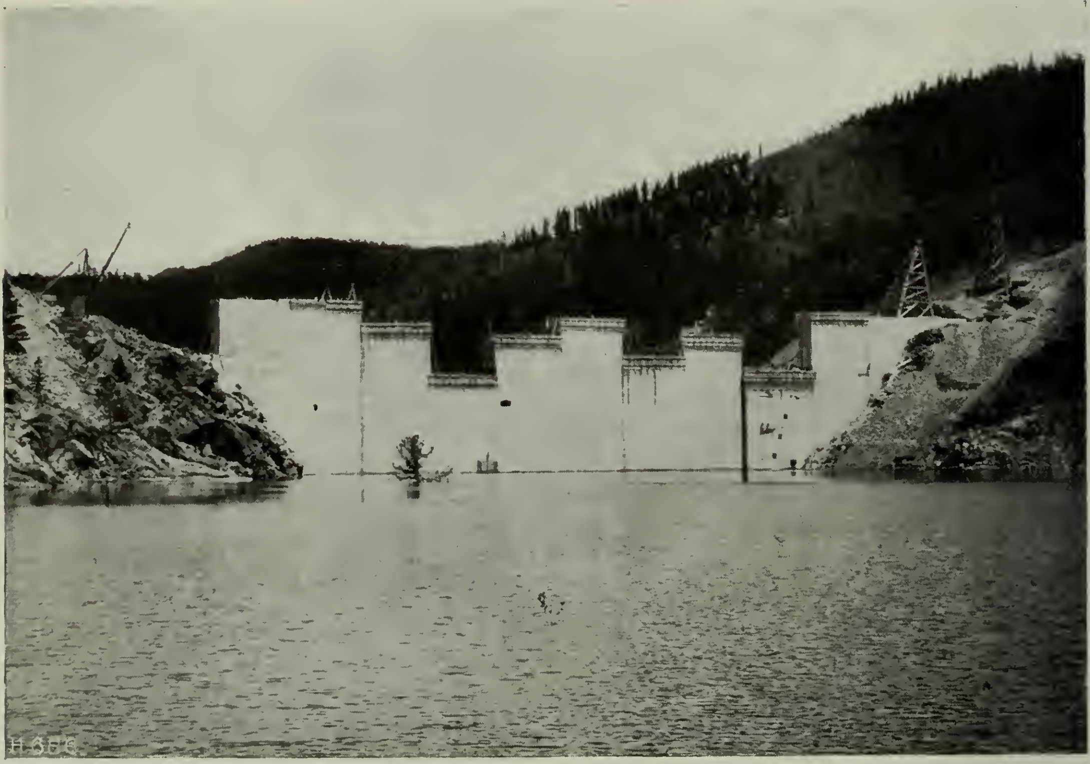
The dam is curved in plan, arched upstream on a radius of 150 ft. at the top. It is 108 ft. thick throughout the section from bed rock to the bottom of the stream, and above this tapers in at the rate of 3 in. to the foot on the down-stream face and 1·8 in. to the foot on the up-stream face, so that the thickness at the top is 10 ft. A spillway is provided in a channel and tunnel cut through the rock around the east end of the dam. The channel starts on a lip levelled off on the east side of the canyon above the dam, about 10 ft. below the crest. A concrete weir wall is built around the edge of this lip, and at the back a trench is cut in the wall, leading to a tunnel, 20 ft. square and 500 ft. in length, which passes through the canyon wall around the abutment of the dam and discharges through another trench into the river below.



View in course of construction.
SHOSHONE DAM, WYOMING, U.S.A.

The outlet works for leading the water to the irrigating canals consist of two tunnels through the rock around the west abutment. One of these is at the stream-bed elevation. It is 10 ft. square and 500 ft. long; 110 ft. above is the second tunnel, for supplying the high level canal systems for assisting the spillway in flood discharge and for furnishing hydro-electric power. This tunnel is about 9 ft. square and 300 ft. in length. In addition to these openings there are also 42 in. iron pipes through the body of the dam at stream level. These pipes are to supply water for power purposes. The gates for the control of the flow in the tunnels and pipes are electrically operated, the machinery being located in openings cut in the rock walls.

Concrete mixing was done at the site, on a bridge spanning the gorge, for lack of sufficient foothold at the sides. The materials for the concrete were obtained from two quarries on the east side above the dam. One of these was the excavation of the spillway-lip and trench, while the other was purely a quarry operation near by. A tramway from the spillway excavation and a chute from the other quarry conveyed the broken granite to a crusher and pulveriser-house located well up on the side of the canyon. In this building it was reduced to the usual sizes for concrete, and to sand. The crushed stone and sand were taken by separate conveyors to two bins on the river bank near the bottom of the canyon. A cement store-house of 12,000 barrels capacity stood directly beside the bins, while a second store-house of 10,000 barrels capacity was located a short distance above.



Upstream face of dam, nearing completion.
BARKER DAM, BOULDER, U.S.A.

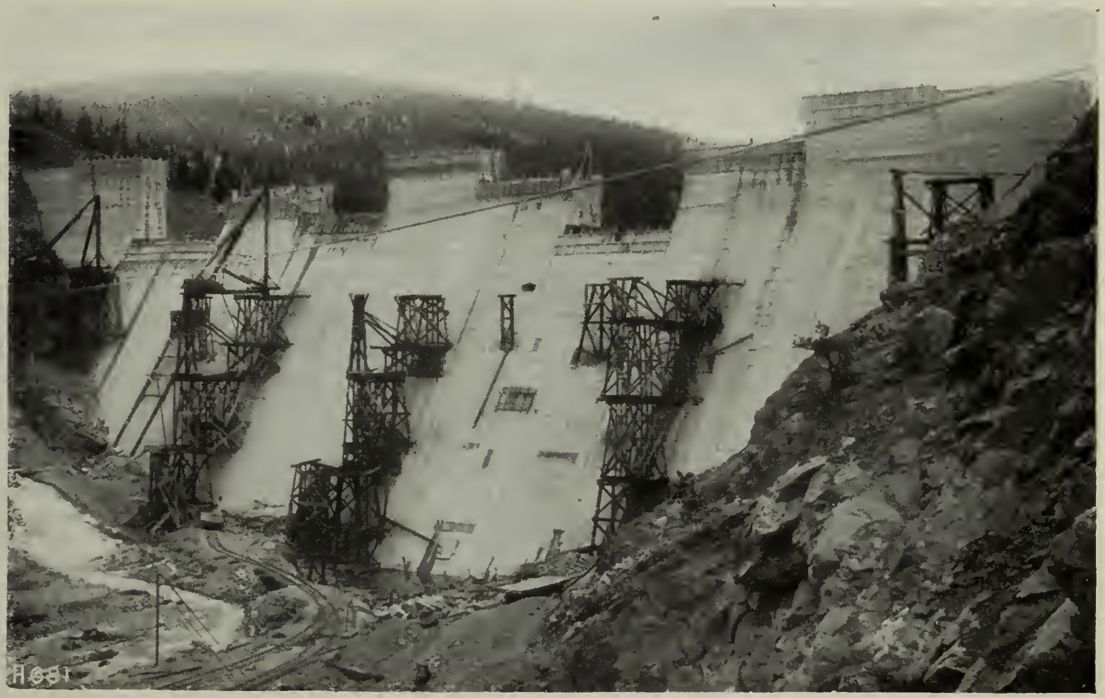
A conveyor passed in front of the stone and sand bins and carried those materials 500 ft. along a trestle-structure on the side of the canyon and up above the top of the mixer bridge, just up-stream from the dam, delivering them to four bins on that bridge. A second conveyor, constructed specially of a cable equipped with small carriages to hold bags of cement, was operated between the cement store-house and the mixer bridge, a distance of about 600 ft.

The mixer bridge was a steel truss structure, spanning the gorge immediately up-stream from the dam, at an elevation slightly above stream level. Concrete for the bulk of the work was discharged into camp buckets, which were picked up by the derricks above and lifted into place. For a part of the work just below the mixers, however, it was possible to place it by chutes. The mass concrete in the dam contains about 25 per cent. large stones, weighing from 25 to 200 lb.

Cantilever timber forms were employed, the bottom of a low section being attached to the finished concrete masonry. As the work progressed the sections of forms were removed and re-erected above.

BARKER DAM, NEAR BOULDER, COL., U.S.A.

ANOTHER large dam, to have a height of 185 ft. above the foundation, and to contain 140,000 cu. yds. of cyclopean concrete, is being built across Middle Boulder Creek, 17 miles west of Boulder, Colorado, as a part of a hydro-electric development by the Eastern Colorado Power Company. The top of the dam is to be 16 ft. in width. It will have a 13-ft. walk across it from one hill to another, as a separate spillway is to be provided in an excavation through the hill at the north end of the dam. It has an elevation of 8,000 ft. above the sea. The canyon of the stream is very narrow at this point, the length of the dam being only 250 ft. at the bottom. and 625 ft. at the crest. The front face is vertical for 20 ft. 6 in. from the top down to a curve, with a radius of 37·7 ft. that connects it with a batter of 6·25 on 10, extending down to 8,080 ft. above sea level, from which height the batter is 7 on 10 to the bottom. The maximum width of the structure at the base is, therefore, 124 ft. Above 8,040 El. transverse expansion joints are placed entirely through the dam at intervals of 48 ft. Vertical grooves are placed in the bulkheads which form the ends of the sections to secure an anchorage between the latter.



Downstream face of dam, in course of construction.
BARKER DAM, BOULDER, U.S.A.

The masonry consists of a 1 : 3 : 5 mixture of concrete containing cyclopean stones. The fine aggregate consists of a mixture of sand and of screenings from crushed gravel and rock ; the large aggregate is crushed gravel and rock. The only limitation placed on the percentage of large stones embedded in the body of the dam is that these stones shall be, at least, 6 in. apart at all points, and the same distance from the faces of the dam and the expansion joints.

The concrete was mixed in a plant erected towards the top of the hill at the north end of the dam, and was handled in buckets from this plant to place by means of cableways spanning the canyon on the axis of the site. The concrete mixing plant is specially well equipped and arranged, giving it a capacity for delivering a large volume of material. It comprises four units, each consisting of a crusher, a screen, two storage bins, a measuring hopper, and a mixer. These units are grouped in one building, which is so arranged on the side of the hill that the materials are passed through the plant almost entirely by gravity.

On the down-hill side of the row of bins is a measuring floor, directly over the row in which the four mixers are placed. The arrangement of the equipment on this floor is such as to facilitate the rapid and accurate proportioning of the materials for each batch, in order that the mixers may be operated to their full capacity without delay on this account. The outlet from each of the two storage bins included in a unit of the plant is a steel chute controlled by an undercut gate. The latter is 14 ft. above the floor over the mixers, and is controlled directly by hand from this floor. Each pair of chutes is set to deliver to a measuring hopper over the respective mixer. The cement is delivered to the measuring floor from a storage house having a capacity of 100,000 sacks that is erected on the side of the hill 250 ft. down-stream from the mixing plant. One of the tracks extending along the up-hill side of the latter is continued to reach the full length of that side of this house. The cement is shipped sacked from the mill in narrow-gauge box cars, which are brought in over the railroad, and thence over the contractor's tracks directly to the house. The cement is loaded out on small, flat cars as required, and delivered over a track extending along the down-hill side of the house to the measuring floor over the mixers. The track being on a sight down grade toward the plant makes it possible to handle large loads on these cars.

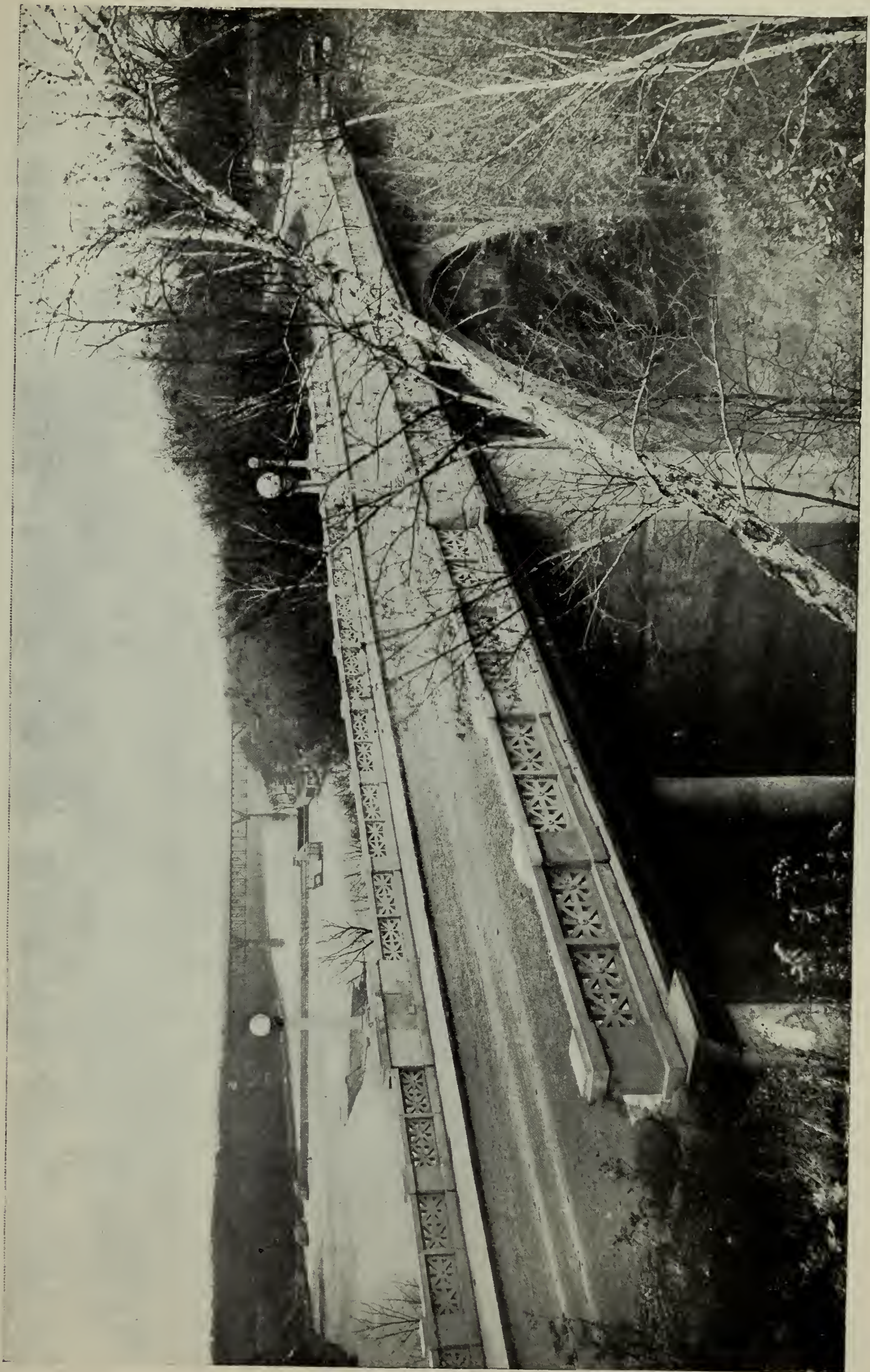
Concrete is laid simultaneously in the separate sections of the dam defined by the transverse expansion joints ; but the height of these sections is kept at different levels to permit the joints to be formed.

The forms for the face of the dam and the expansion joints are made in 28-in. by 12-ft. sections, which are stripped and moved up as the level of the concrete work progresses. The concrete is spaded against the face of the forms to produce a finish on the exposed surfaces of the dam and of the expansion joints. Good results were thus secured without rubbing the concrete, or otherwise working it, after the forms are stripped. The cyclopean stone was wet thoroughly at the quarries, and again at the dam before being placed in the concrete masonry. The concrete was also sprinkled continuously during the day to prevent drying before it had set properly.

Mr. M. J. Beisel is superintendent in charge of the product for McArthur Bros., the contractors, and Mr. A. W. Gray, the engineer in charge, for the Eastern Colorado Power Company.

REINFORCED CONCRETE BRIDGE AT ST. PAUL, MINN., U.S.A.

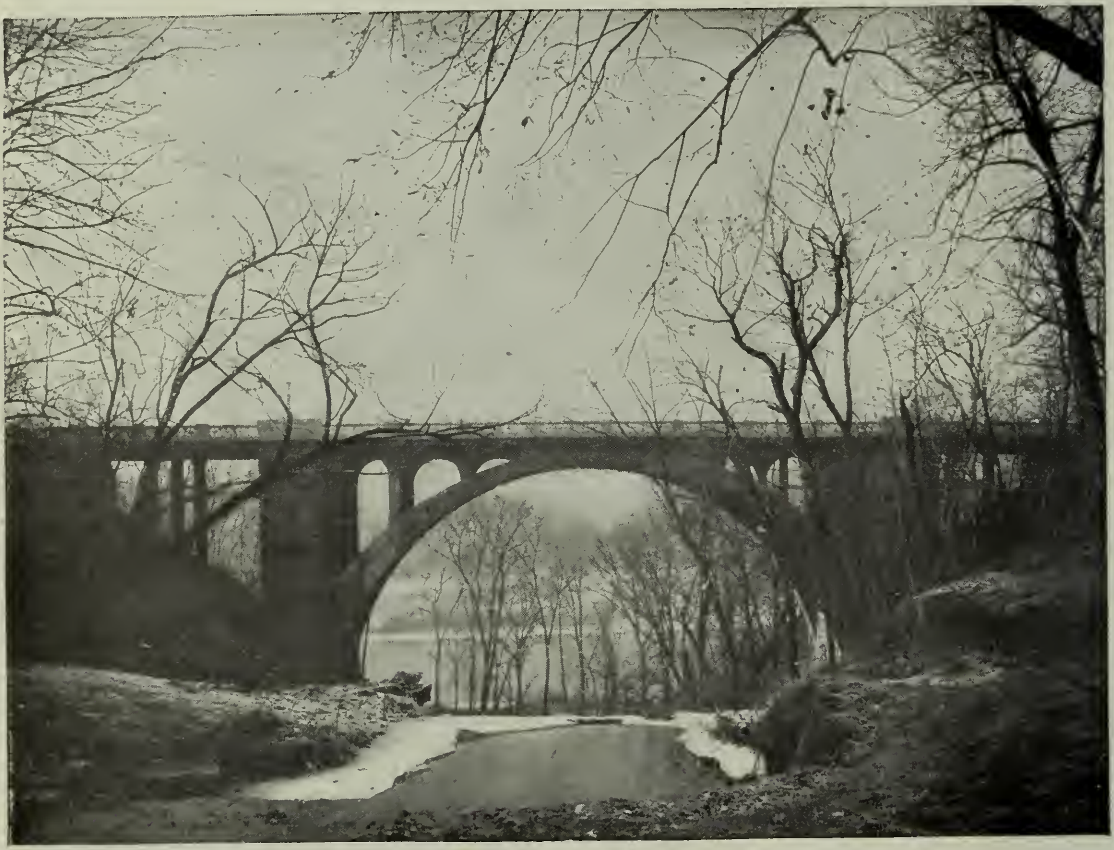
THE view on page 37 is of a reinforced concrete bridge on the Mississippi Boulevard at St. Paul, Minn., U.S.A., built on the " Mushroom " system of reinforced concrete construction. The height of the bridge from the floor to the bottom of the ravine it spans is 95 ft. A side view is shown on page 38, which gives a good



Reinforced Concrete Bridge at St. Paul, Minn., U.S.A.

idea of the character of the span and general location. The large abutments are hollow boxes of reinforced concrete about 6 in. thick. These abutments furnish excellent bracing, and give the bridge a massive appearance from the architectural standpoint, while the independent framework of the ribs, with the mushroom strut braces, meets all requirements from the standpoint of strength. The lamp standards were also made of concrete.

In viaduct construction the standard mushroom design consists of a length of trestle broken at intervals by hollow box piers, at which expansion joints are made, and which serve to divide the structure into a series of units, giving a pleasing appearance. We are indebted to *The Cement Age* for the illustrations of this bridge.



Side view of bridge.
Reinforced Concrete Bridge at St. Paul, Minn., U.S.A

McINTYRE BUILDING OF REINFORCED CONCRETE AT SALT LAKE CITY, U.S.A.

A very fine reinforced concrete building has just been completed in Salt Lake City, U.S.A. It is 50 ft. by 135 ft., having eight storeys and basement. The walls, floors, columns, beams and stairs are built entirely of reinforced concrete. It has light courts on the sides, and is entirely fireproof throughout, the only wood used being the hand-rail on the stairs. The floor slabs are 3¾ in. with 3 in. concrete and 1½ in. cement topping, and are reinforced with Kahn rib metal.

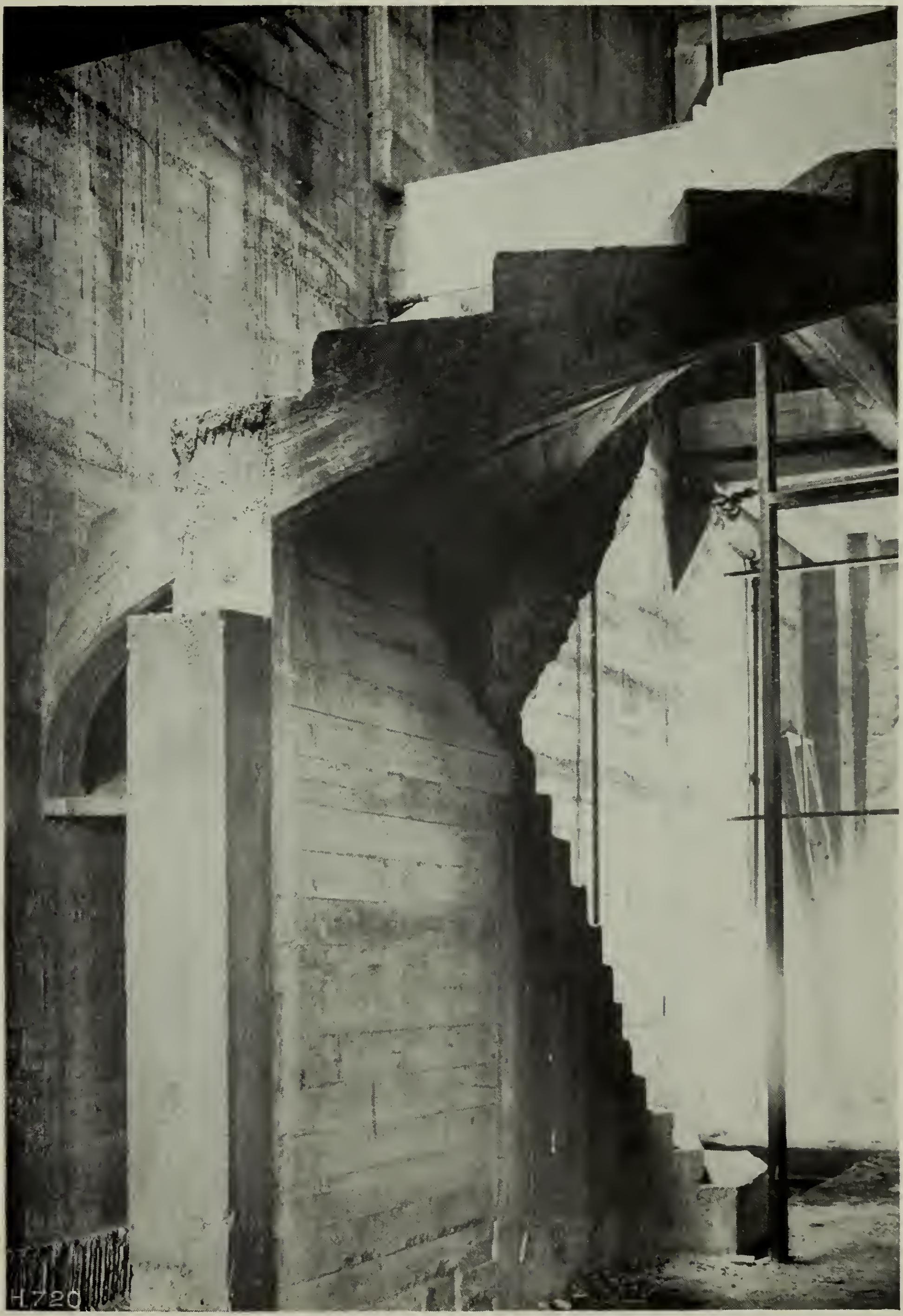
The main beams are 12 in. by 24 in., while those carrying both courts are 14 in. by 28 in., the small division beams run 10 in. by 20 in., reinforced with Kahn bars.

The front entrance is wainscotted to ceiling with marble. The design of the front shows a thoroughly modern and effective concrete construction, plastered with white Medusa cement, with cast ornaments.

All stairs, together with main circular stair at main entrance, shown in our illustrations, are concrete with marble treads and risers.

Fire escape platforms are made of concrete slabs.

The architect for this work was Mr. R. Klettering, of Salt Lake City.



Concrete stairway construction.
McIntyre Building, Salt Lake City, U.S.A.

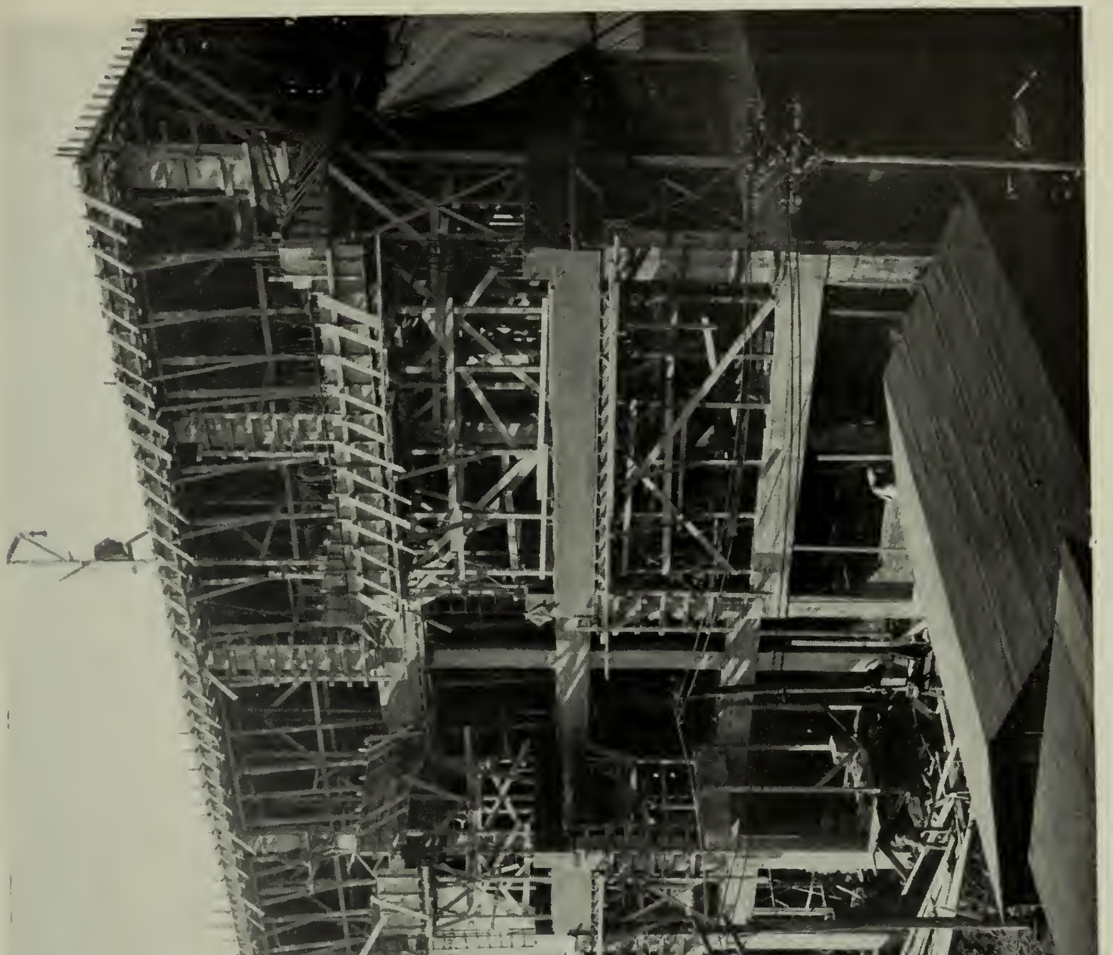
STORAGE BUILDING FOR THE PIERCE ARROW MOTOR-CAR CO., BUFFALO, U.S.A.

The illustration on page 41 shows a view of the Pierce Arrow Motor-Car Co.'s new storage building in course of construction.

The main building has floors and roofs of the girderless or mushroom type, the floor being designed for live loads of 150 lb. to the sq. in. The exterior walls have a framework of reinforced concrete columns and girders.

Concrete stairway construction.
McIntyre Building, Salt Lake City, U.S.A.

The area of the main part of the new building is 308 ft. by 62 ft., and has a 102 ft. by 50 ft. wing extending towards the assembly building. The ground-floor rooms are 16 by 29 ft. high; second and third floors 15 ft., and fourth floor 15 ft. high.



View of building in course of erection.
Reinforced-Concrete Storage Building for the Pierce Arrow Motor Co., Buffalo, U.S.A.

The floors are girderless and are supported by columns 20 ft. 6 in. on centres, the column heads flaring at the top to a diameter of 56 ins. The floor slabs are 8 in. thick of 1 : 2 : 4 concrete reinforced with strips 9 ft. wide, made up of 17½ in. rods running at right angles, parallel and diagonally to the lines of the columns.

These rods extend well over the column heads, which are further reinforced with eight 1-in. rods extending 4 ft. down into the columns and radially out into the floor slabs about 3 ft. 9 in., so that their ends are on the circumference of a circle about 8 ft. in diameter. The radial rods are bent over a 2-in. by ⅝-in. hoop at the column head and are wired to 1-in. iron rods bent into circles, one about 4 ft., and the other 8 ft. in diameter. In the ground and first floors the 8-in. structural slab is covered with 1-in. granolithic finish, made of 1 part cement, 1 of sand, and 1 of granite dust.

The floors were tested about 90 days after the concrete was placed, one panel being loaded with castings weighing 120,000 lb., or 226 lb. per sq. ft. Although this is nearly double the live load the floor was designed to carry, it only showed a deflection of $\frac{3}{32}$ in. at the centre of the panel.

The contract for the building was placed with the Aberthaw Construction Co., of Boston, U.S.A., and the whole building was erected in the remarkably short period of three months.

TESTS WITH REINFORCED CONCRETE COLUMNS.

The report summarised in the following article has been published in Berlin by Messrs. Wilhelm Ernst & Son, the technical publishing house that has recently issued several important works on reinforced concrete. The German title is "Versuche mit Eisenbeton-Säulen." The price is 6 M.—ED.

PROFESSOR RUDELOFF'S report deals with experiments undertaken at the Royal Material-Testing Station at Gross-Lichterfeld, Berlin, at the instance of the German Reinforced Concrete Committee. The experiments, which were continued over the period 1907-1909, were particularly directed to the determination of the influence of different kinds of transverse reinforcement on the strength of columns.

First Series.—Designs for reinforced concrete columns were furnished by Messrs. Hüser & Co., The Concrete & Monier Construction Co., and Messrs. Dyckerhoff & Widmann. All the columns were 2 metres long, and 13 different forms of transverse reinforcement were used, as shown in *Fig.* 1. All the columns were of rectangular section, 30 cm. square, except Nos. 12 and 13, which were of the same area, but octagonal in form, each edge being 13·65 cm. The longitudinal reinforcing rods were 16 mm., and the transverse 7 mm. in diameter. The transverse reinforcement was placed at equal intervals of 20 cm. All were prepared from the same mixture of 1 part cement and 3 parts of an aggregate prepared by mixing graded gravel and sand in the proportions required to give a product with a minimum of voids. The cement, from the Lossius-Delbrück Portland Cement Works, Züllchow, and the steel, from the Phœnix Co., of Hoerde, Westphalia, were tested before the experiments, and were found to comply with the standard requirements for a slow-setting cement and a mild steel respectively.

Preparation of the Columns.—As the result of some preliminary experiments, 9 per cent. of water was used in preparing the first column, but this being, in the opinion of those who witnessed the operation, too little, was increased to 9·5 per cent. for all the remaining columns. The water originally present in the aggregate was allowed for in all cases. The volume weights of the cement and aggregate were determined on quantities of 10 litres, and thereafter all materials were weighed instead of being measured. The concrete was mixed for ½ minute dry and 2½ minutes wet in a Hüser mixing machine, and each quantity of 200 kg. was covered with wet cloths until actually used. The concrete was rammed in vertical wooden moulds, which were wetted and not oiled.

The columns remained for 3 days in the moulds and then for 10 to 12 days standing on the iron base, the wooden moulds being removed. After this they were preserved under a thick layer of moist sand until 10 days before they were required. They were then transferred to the laboratory, placed horizontally, and their ends made accurately parallel by finishing with cement between steel plates. It was found that this layer of cement was perfectly preserved throughout the testing.

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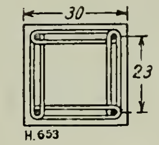
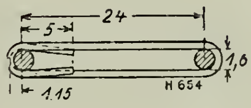
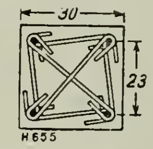
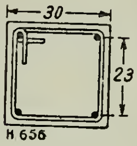
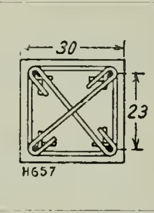
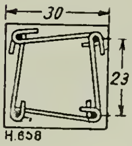
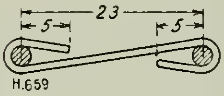
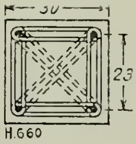
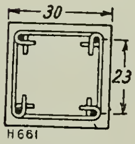
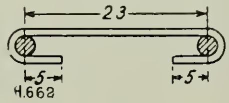
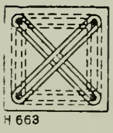
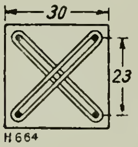
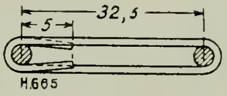
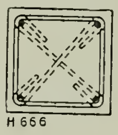
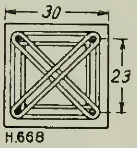
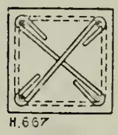
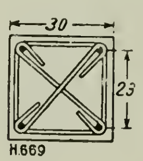
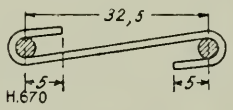
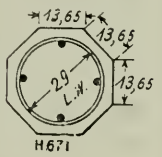
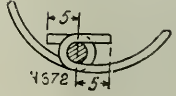
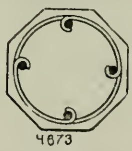
1			8		Like Nos. 3 & 7.
2		5 cm. hooks as in No. 1.	9		Like Nos. 4 & 7.
3			10		Like Nos. 1 & 5.
4					
5			11		Like Nos. 2 & 7.
6		Like Nos. 1 & 5.			
7		 Hooks like No. 2.	12		Hooks. 
			13		Hooks, as in No. 12.

FIG. 1.

The compressive strength of cubes of this concrete, when mixed with 9·5 per cent. of water, was on the average 189 kg. per sq. cm., whilst when only 7 per cent. of water was used it was as high as 264 kg. per sq. cm., or 40 per cent. greater.

Performance of the Tests. — All the tests were performed on columns 45 days old, a vertical 600-ton testing machine being used, equipped with a modified form of Martens' mirror apparatus for measuring the changes in length between two points 1 metre apart, and with special lever appliances for measuring the expansion in the direction of one of the diagonals (*Fig.* 17).

The measurements obtained are recorded in a very lengthy series of tables. The following points became evident in the course of the tests :

Shifting of Reinforcing Loops. —In accordance with the practice of the firms concerned, the transverse reinforcing rods or loops were not attached to the longitudinal rods by means of wires, but simply bent and set in place as the level of the concrete rose. The result was that they became displaced during the subsequent ramming, and very few were found to have retained their proper positions. The position of the fracture appeared, however, to be independent of the displacement. In some cases the transverse loops were no longer parallel, but no bending outwards of the longitudinal rods was observed at the points of greatest separation of the loops.

Influence of the Longitudinal Reinforcement. — Experiments in which loads were repeatedly applied and removed showed that for small loads the compression was practically the same each time the load was applied, but that for heavy loads the compression increased, and was not constant even after ten applications. This is of importance, as the figures show that, although the longitudinal rods were permanently shortened by such treatment, the load applied to them was far below

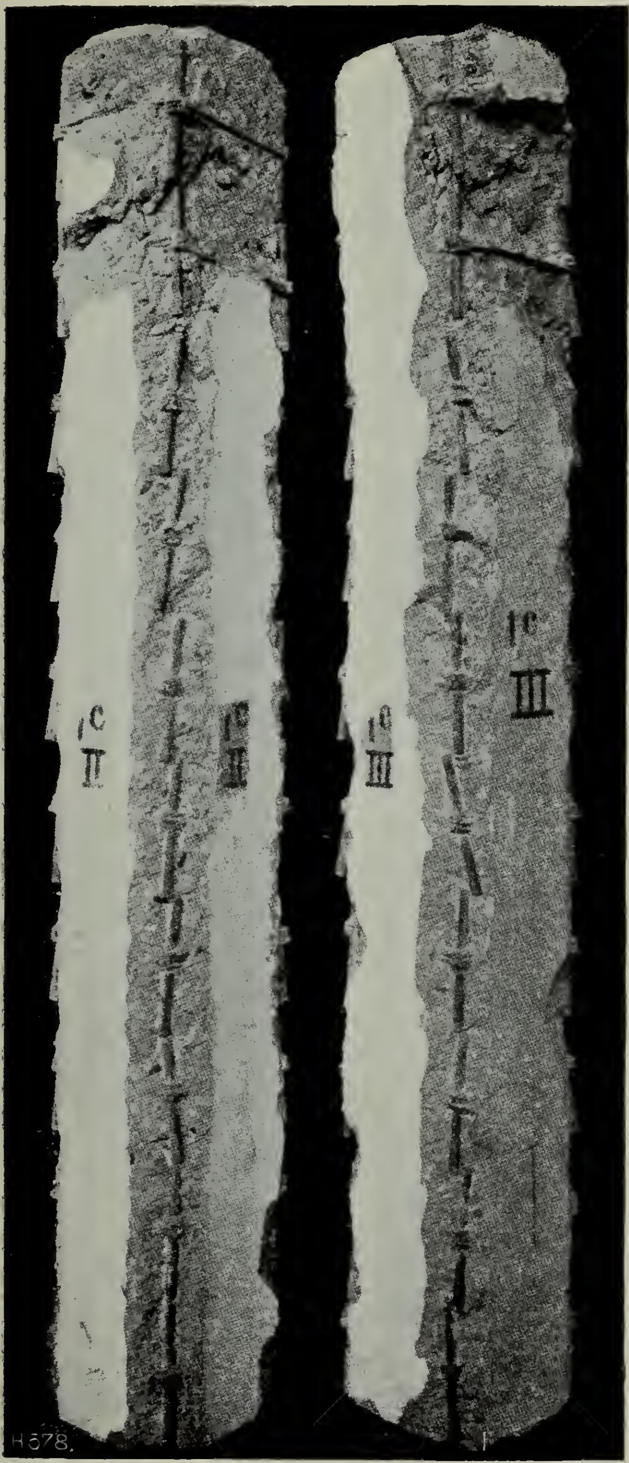


Fig. 2. Longitudinal Reinforcement in lengths of 20 cm. Transverse Reinforcement of four loops each.

their elastic limit. It follows, therefore, that the distribution of stress between the steel and the concrete must have been greatly altered during the loading, the proportion of the stress borne by the steel being increased. As the steel was not

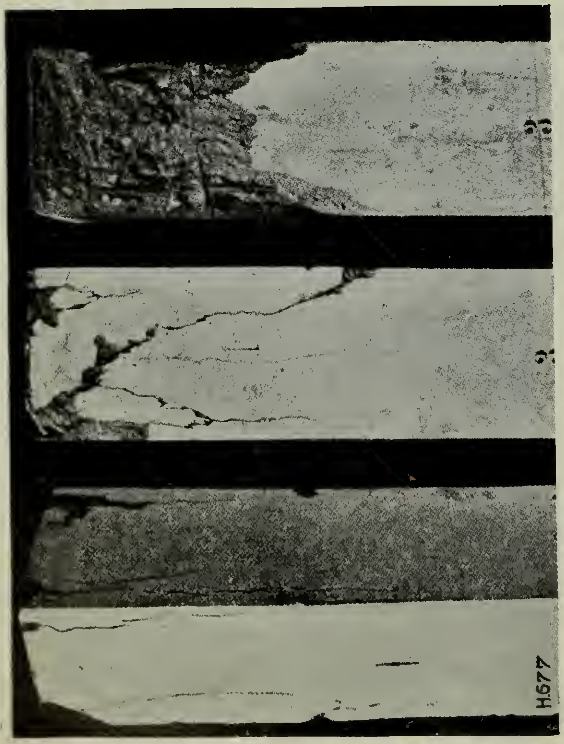


Fig. 3. Columns 3. Showing First Development of Cracks and Ultimate Fracture.

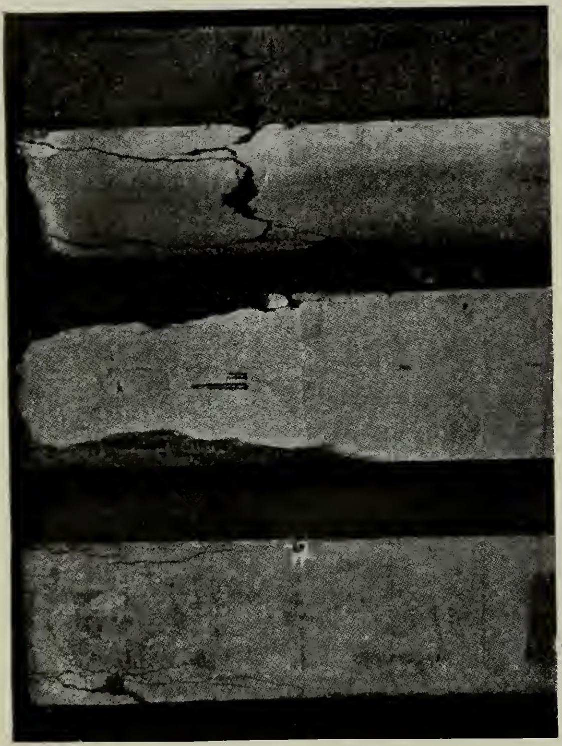


Fig. 4. Columns 4.c. On further Crushing Transverse Cracks appeared below the Reinforcing Loops.

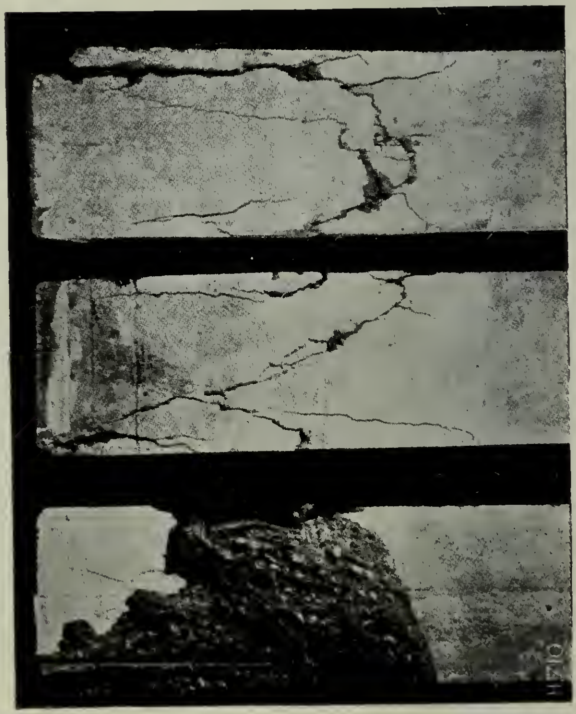


Fig. 5. Columns 5. First Cracks Longitudinal, and Later Cracks Oblique.

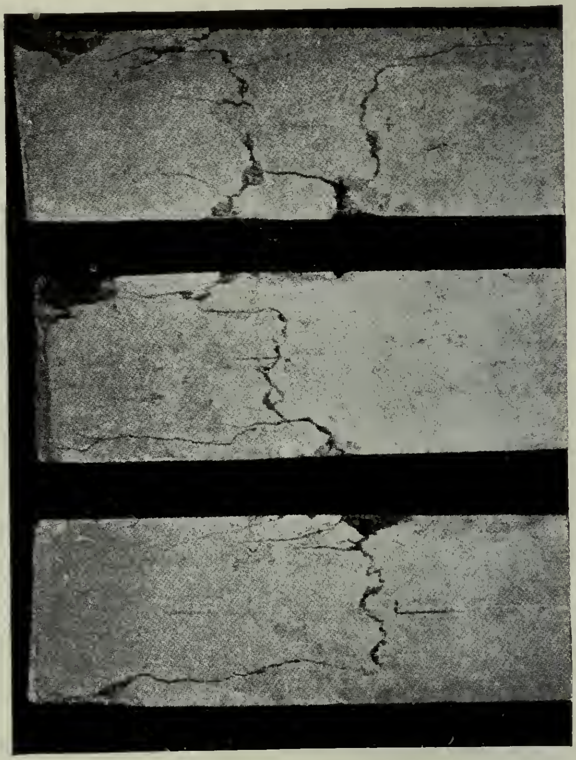


Fig. 6. Columns 6.

found, after destruction in the machine, to have slipped, it follows that the compressive stresses in the steel must have been balanced by tensile stresses in the concrete; in fact, the permanent compression in such columns was found to be less than in similar columns without reinforcement, subjected to the same loads and to the same number of alternations.

Influence of the Type of Transverse Reinforcement.—The numerical results of the tests are summarised in Table I. Each result is actually the mean of the results obtained from three exactly similar columns. The numbers refer to the sketches of reinforcement in *Fig.* 1, where details are given. All the loads are expressed in kilograms per square centimetre.

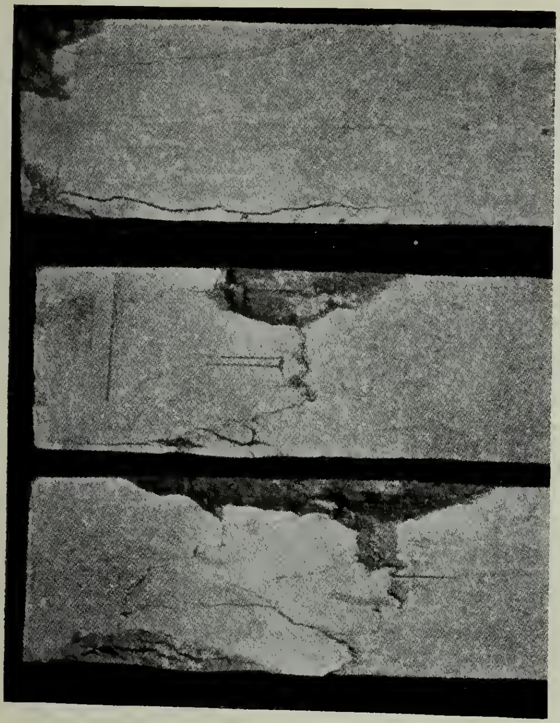


Fig. 8. Columns 8.

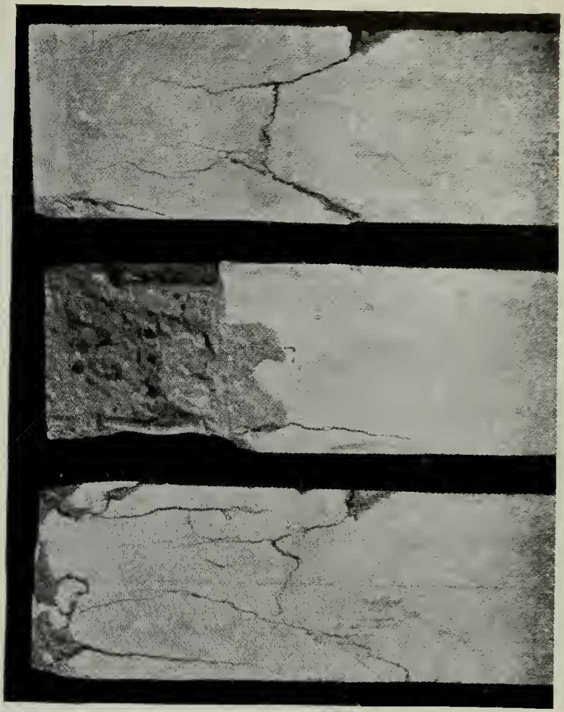


Fig. 10. Columns 10.

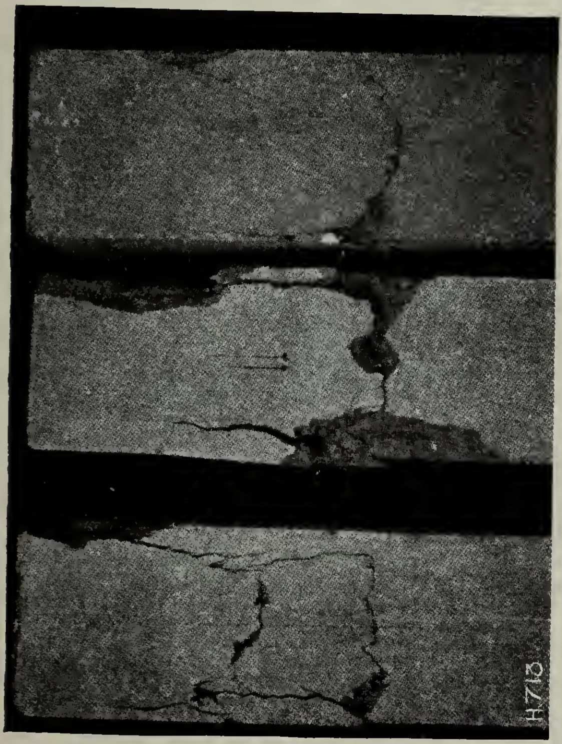


Fig. 7. Columns 7. Corners Split Off and Longitudinal Rods Bent.

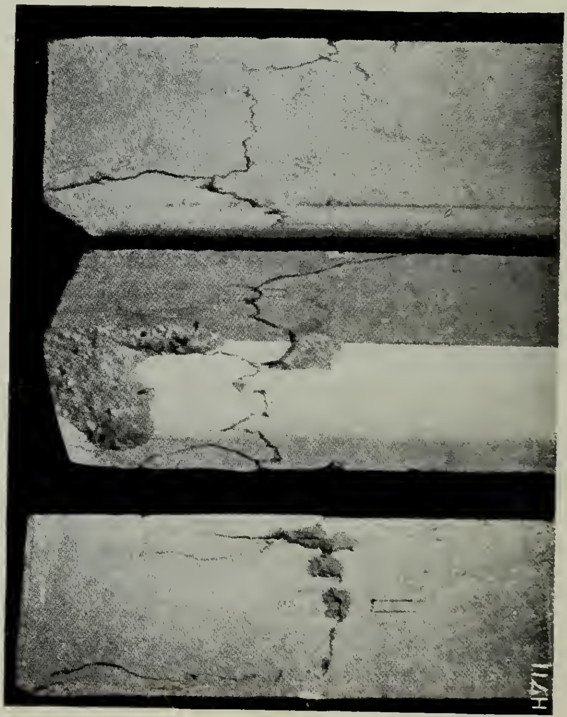


Fig. 9. Columns 9.

A comparison of columns 1*a*, 2*a*, and 12*a*, which had no longitudinal reinforcement, with the non-reinforced columns "O" shows that transverse reinforcement alone is practically without influence on the amount of compression. On the other hand, when longitudinal reinforcement is present, its influence is greatly assisted by the presence of transverse reinforcement. Reinforcing rods or loops parallel with the sides are much more effective than diagonal loops, and in such cases as columns 6 and 9 the presence of diagonal as well as lateral reinforcement results in an actual increase of the deformation, instead of a decrease. The measurements

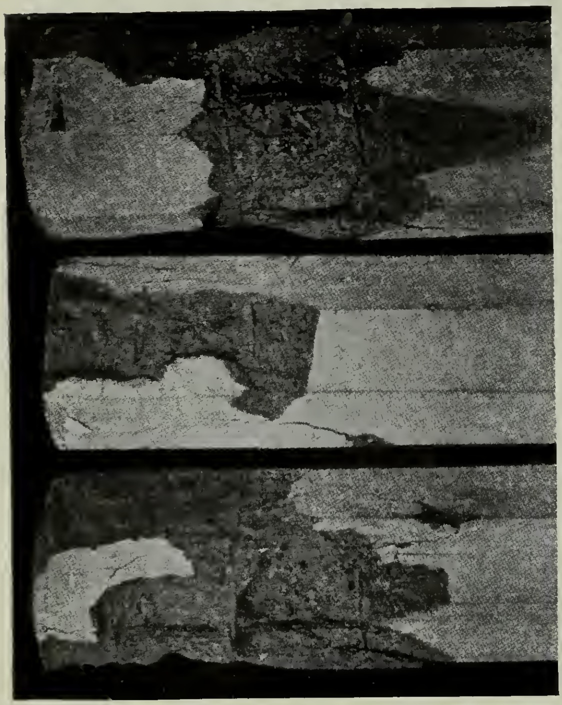


Fig. 12. Octagonal Columns 12. Cracks only appeared at the Moment of Fracture.

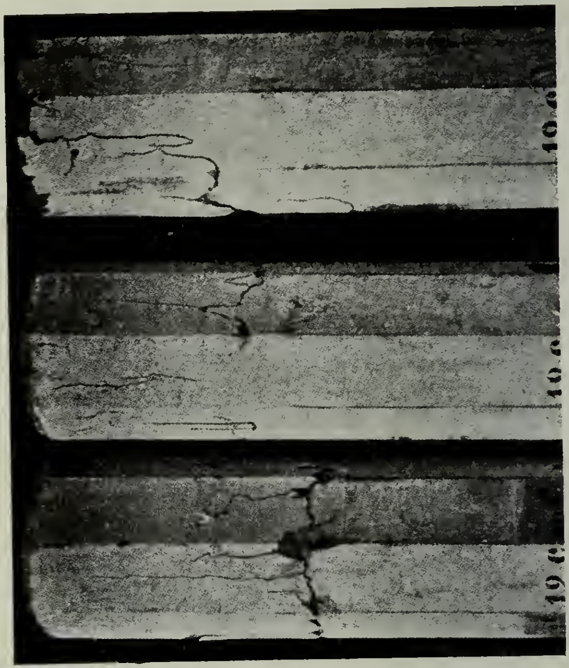


Fig. 14. Columns 12c. Longitudinal Reinforcement cut into short lengths.

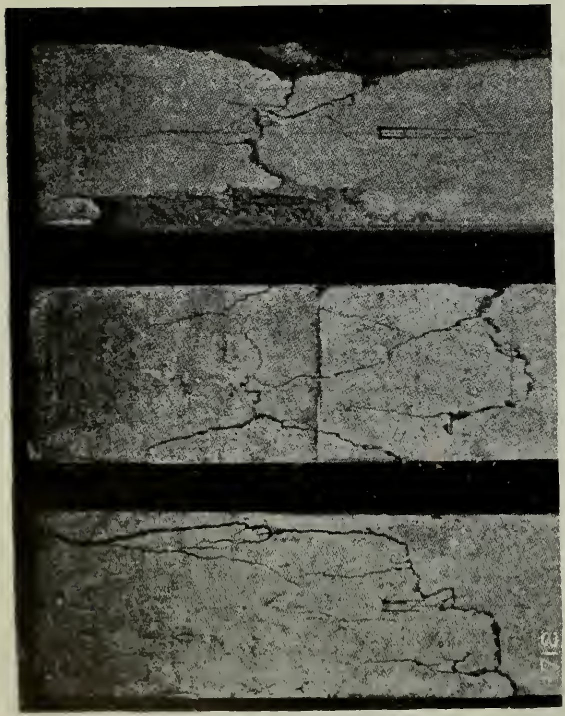


Fig. 11. Columns 11. The Transverse Cracks are just beneath the Lateral Reinforcing Loops, not beneath Diagonal Loops.

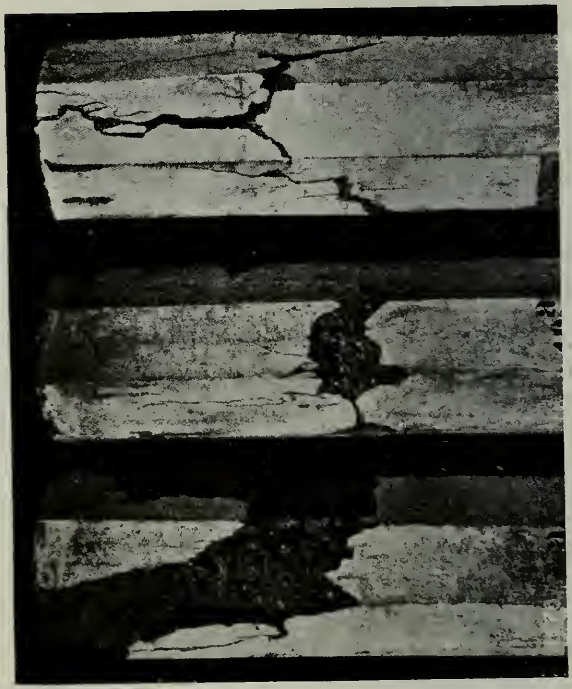


Fig. 13. Columns 12a. Without Longitudinal Reinforcement

of lateral expansion show that, almost without exception, great expansion accompanies great compression. The figures for expansion are therefore not reproduced in the present abstract. The ratio between compression and diagonal expansion is irregular, but has an average value of 6·5.

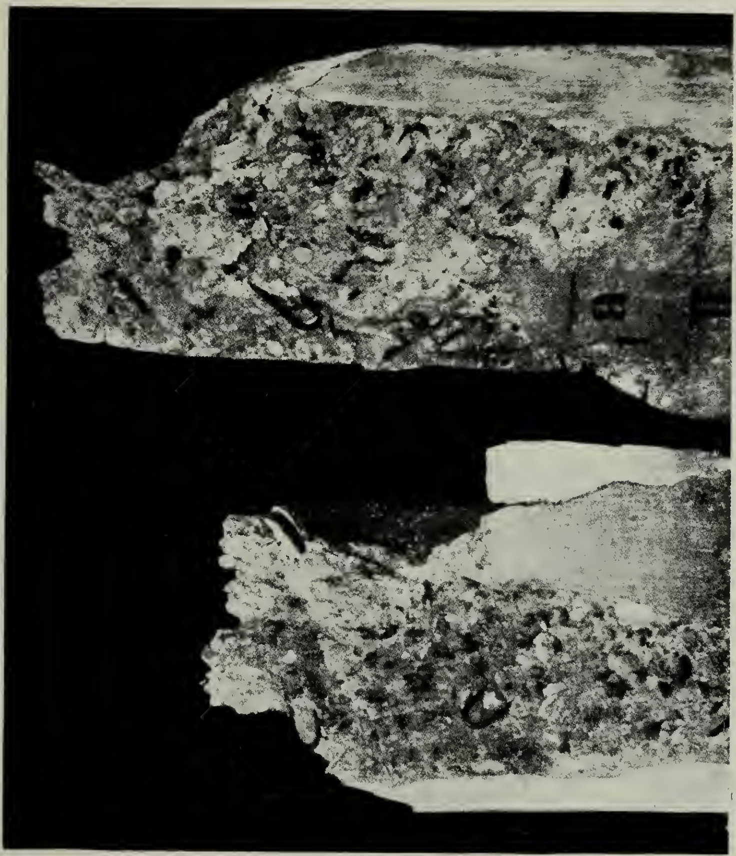


Fig. 16. Column Ia II, showing displacement of Reinforcing Loops during ramming.

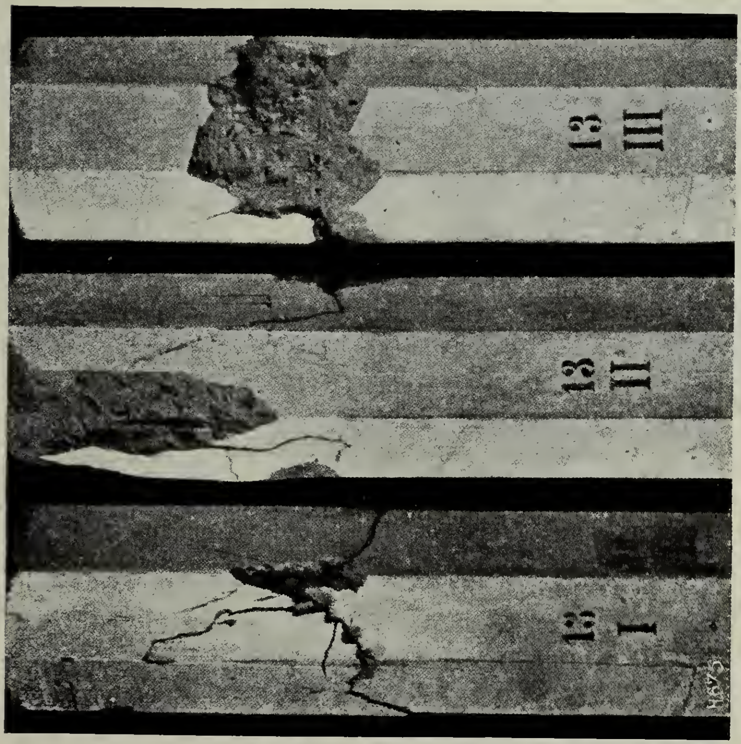


Fig. 15. Columns 13.

Crushing Strength of the Columns.—Notes were made of the state of the weather at the time of preparation of each column, and the results show that those prepared in moist, rainy weather were always weaker than those prepared in dry weather with the same reinforcement. Every column broke at the end which was uppermost during ramming, whether this end was placed upwards or downwards in the machine during testing, showing clearly that the solidity of a concrete column diminishes towards the upper end. Measurements of the specific gravity after saturating with water showed that the concrete diminished in density upwards.

Longitudinal reinforcement alone has little or no influence on the strength, but increases the modulus of elasticity. Reference may be made to a few columns in which the longitudinal reinforcement was not continuous, but was cut up into lengths of 20 cm. The results obtained were variable, but *Fig.* 2, which represents one of these columns after testing and trimming off the corners, shows that these short lengths of rod are forced into an inclined position by the load.

The appearance of the beams after testing is shown in *Figs.* 3 to 16. The type of reinforcement used in each column may be found by reference to the corresponding number in *Fig.* 1. The general conclusion to be drawn is that the type of transverse reinforcement employed has a surprisingly small influence on the strength of the columns, certainly less than the conditions under which the columns are prepared and rammed. The results indicate, however, that transverse reinforcement consisting of a continuous rod wound round the longitudinal rods and bent over at the ends gives better results than short rods hooked at each end. Diagonal reinforcement, or alternately diagonal and lateral, is unfavourable, as is seen particularly in the fact that columns reinforced in such a manner develop cracks long before the application of the ultimate breaking load. Lateral reinforcement leads to the development of transverse cracks and to the shattering of the concrete, but only when the ultimate breaking load is reached. Octagonal columns also behave better when reinforced with a single rod wrapped completely round than with a number of short-hooked rods. The peculiarities of the fractures in each case are best seen from an inspection of the photographs.

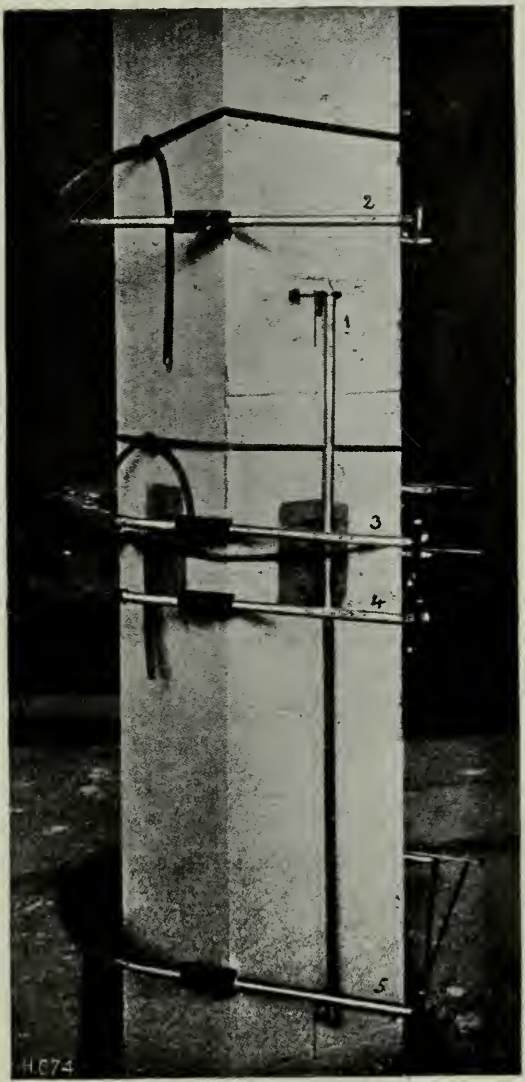


Fig. 17.

Second Series.—The results of the foregoing tests having been discussed by the committee, it was decided to carry out certain further experiments, utilising the experience already gained. Columns were prepared from the same materials (the later consignment of cement, however, giving a stronger mortar), but the ballast was sifted and graded, and definite quantities of each grade used. The proportion of water was reduced to 8·2 per cent., and the wooden moulds were neither oiled nor wetted. In order to avoid the influence of weather the columns were prepared indoors. The transverse reinforcing loops were placed 15 cm. apart, and in order to guard against accidental displacement were wired to the vertical rods before introducing the concrete. The steel pins required for the measurements were rigidly attached to the reinforcing rods instead of being inserted in the concrete as in the first series.

The types of reinforcement used are shown in *Fig.* 18. It will be seen that, in addition to some minor modifications in the arrangement of the reinforcing loops, the octagonal columns, 19 and 20, were prepared with 8 longitudinal reinforcing rods, No. 19 having spiral reinforcement and No. 20 reinforcing rings. The spirally reinforced columns were constructed under the direction of Messrs. Wayss & Freytag. The total length of each column was only 90 cm. instead of 2 metres, and the changes of length were measured between points 50 cm. apart.

Results of the Tests. — The numerical results are summarised in Table II. As before, each result is the mean of the results from three exactly similar columns. The numbers correspond with those in *Fig.* 18, from which the nature of the reinforcement may be found.

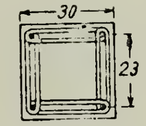
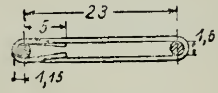
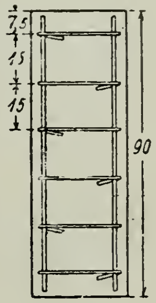
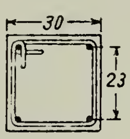
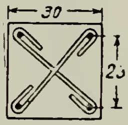
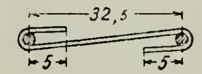
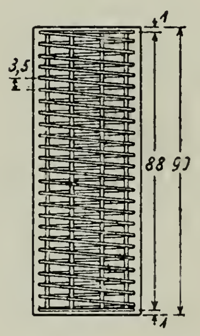
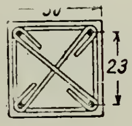
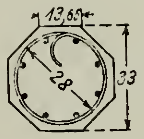
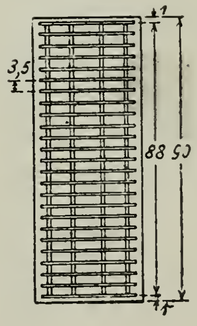
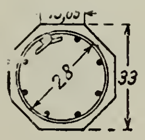
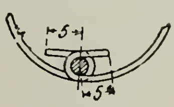
No.	Cross Section.	Details.	Vertical Section.
14			
15		Length of hook, 5 cm.	
16			
17		Hooks as Nos. 15 and 16	
18	None		
19			
20		Hook 	

FIG. 18.

Transverse measurements at different heights showed that in all cases the columns became bulged under load, although to a less extent than in the columns containing no reinforcement. The columns with S-diagonal reinforcement showed the least swelling. The ratio of longitudinal compression to lateral expansion was much less in the second series than in the first, being about 2·3 instead of 6·5. This difference is probably due to the greater density of the concrete in the second series, the denser concrete naturally yielding less under compression.

As before, fracture took place at the end which was uppermost during ramming. The pyramidal fracture was generally well developed. The ultimate fracture of the spirally reinforced and hooped columns was accompanied by the breaking of the hoops at several distinct points.

The greatest strength was given by the spirally reinforced octagonal columns, the hooped octagonal columns coming next in order. The columns without reinforcement were the weakest. Of the square columns, the best results were given by the O-loops (14) and the worst by the continuous reinforcement (15), this result being in decided contradiction to that obtained in Series I. As before, it was found that the presence of diagonal as well as lateral reinforcement in the same section actually weakened the columns.

TABLE I.

No.	Longitudinal Reinforcement.	Transverse Reinforcement.	Compression in Parts per 10,000,000 under 87 Kg.	Load at		Relative Strength.	
				Cracking. Kg.	Fracture. Kg.	Cracking.	Fracture.
0	None ...	None	855	140·6	140·6	100	100
1	Continuous...	4 O-links ...	616	133·6	133·6	95	95
2	,, ...	Continuous ...	586	153·4	153·5	105	109
3	,, ...	4 S-links ...	617	158·1	158·1	112	112
4	,, ...	4 C-links ...	705	148·4	154·1	106	110
5	,, ...	2 diagonal ...	654	131·0	151·6	93	108
1*a*	None ...	4 O-links ...	946	131·3	131·4	93	93
2*a*	,, ...	Continuous ...	584	134·0	135·4	95	96
1*c*	Short lengths	4 O-links ...	686	162·9	162·9	116	116
2*c*	,, ,,	Continuous ...	850	129·4	131·6	92	94
6	Continuous...	4 O-links and 2 diagonal	711	119·3	150·9	85	107
7	,, ...	Continuous and 2 S-diagonal	714	124·8	151·2	89	108
8	,, ...	4 S-links and 2 S-diagonals	677	125·8	153·0	89	109
9	,, ...	4 C-links and 2 S-diagonals	744	117·6	135·1	84	96
10	,, ...	Alternately O and diagonal	801	103·4	132·2	74	94
11	,, ...	Alternately continuous and diagonal	539	106·7	136·8	76	97
	Octagonal						
12	Continuous...	Continuous ...	518	157·6	157·6	112	112
13	,, ...	Overlapping rings	—	125·7	145·7	89	103
12*a*	None ...	Continuous ...	726	155·9	156·2	111	111
12*c*	Short lengths	,, ...	700	113·1	131·1	80	93

The steel used for the spiral reinforcement was of exceptionally high tensile strength. It appears that this fact influences the breaking load, but not the point at which cracks appear. Yielding of the hooked ends of reinforcing loops was not observed in any case.

Density of Concrete.—The fact that the upper end of a column always proved to be the weakest part suggested some special experiments with columns not containing any reinforcement. Nine columns were therefore prepared, each 2 metres high and 30 cm. square, in the same wooden moulds. The proportions of cement and ballast were varied, three columns each being prepared of 1 : 2, 1 : 4, and 1 : 6 mixtures. The particulars of the water used in mixing are given in Table III., where the results are summarised. Immediately after ramming samples were taken from the top, middle, and bottom for the determination of the density and water-content. The results show that the proportion of water after stamping is very considerably less than that in the original mixture, lean mixtures losing the least. Only a small part of the loss is to be attributed to chemical combination, as the time elapsing before taking the sample was considerably less than the setting time of the cement. The water-content increased from the base of the column upwards. The proportion of cement increased slightly upwards. On the other hand, the density of the concrete was very markedly greater in the lower portions of the columns.

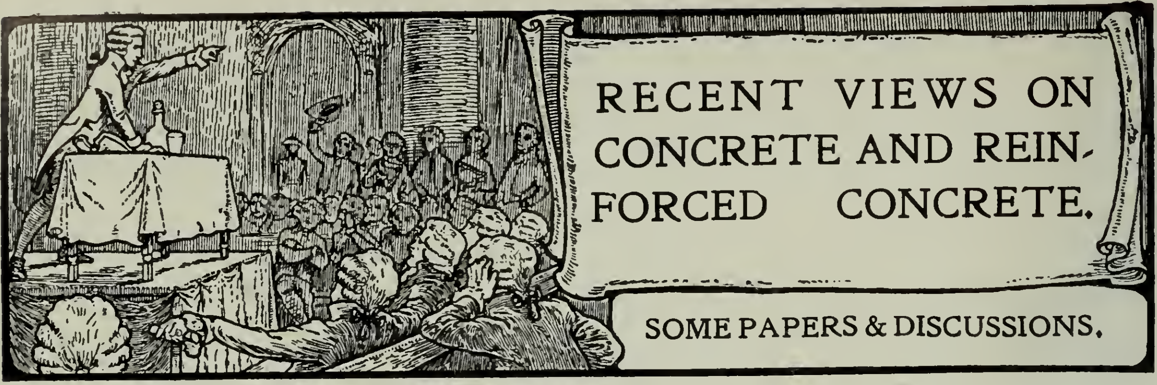
TABLE II.

No.	Longitudinal Reinforcement.	Transverse Reinforcement.	Compression in Parts per 10,000,000 under 113 Kg.	Load at		Mean Stress at Fracture.*	
				Cracking.	Fracture.	Concrete σb	Steel σc
14	4 rods, 16 mm.	4 O-links ...	734	193·5	196·8	192	2,880
15	,,	Continuous ...	853	170·2	176·6	173	2,600
16	,,	2 diagonal S-links	697	185·5	187·0	183	2,750
17	,,	Continuous and 2 diagonal S-links	—	168·0	178·3	175	2,630
18	None	None	1,265	155·4	155·4	172	—
19	8 rods, 11 mm.	Spiral	1,057	191·6	208·6	206	3,100
20	,,	Rings	—	196·4	200·0	197	2,960

* All loads and stresses are expressed in kilograms per square centimetre. The stresses in the concrete and steel respectively are computed in accordance with the Prussian regulations.

TABLE III.

No.	Proportions of Cement and Ballast.	Water, Per Cent.	Density of Dry Concrete.			Per Cent. of Water immediately after ramming.			
			Top.	Middle.	Bottom.	Top.	Middle.	Bottom.	Mean Ratio to Original Per Cent.
I.	1 : 2	8·0	2·29	2·34	2·34	6·8	6·3	5·4	75·7
II.	1 : 2	9·0	2·28	2·29	2·34	6·2	6·5	5·6	75·7
III.	1 : 2	10·5	2·23	2·30	2·28	9·2	8·8	7·8	75·7
IV.	1 : 4	7·0	2·27	2·33	2·34	5·9	5·8	4·9	74·2
V.	1 : 4	8·2	2·24	2·28	2·29	6·8	5·8	5·6	74·2
VI.	1 : 4	9·5	2·19	2·24	2·25	7·2	6·4	6·2	74·2
VII.	1 : 6	6·5	2·23	2·28	2·28	5·0	5·5	5·4	82·5
VIII.	1 : 6	7·5	2·23	2·26	2·30	6·0	5·9	6·0	82·5
IX.	1 : 6	8·5	2·20	2·21	2·20	8·3	7·5	6·0	82·5



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

GENERAL CONCRETE PRACTICE.

Paper by Mr. THOMAS POTTER.

The following is an abstract of a paper under the above title which was read by Mr. T. Potter at the General Meeting of the Concrete Institute held on December 15th, 1910, at the Royal United Service Institution, Whitehall, London, S.W. Sir Henry Tanner, President of the Institute, was in the Chair.

This paper has been confined to the use of concrete in connection with buildings, apart from any association with reinforcement or steelwork, for the consideration of which the limited time at disposal does not permit.

Theory and Practice.—Concrete and its application appear to set most theories at defiance—many that have been proposed hitherto, with every good reason for acceptance, have been negatived in practice. No doubt eventually there will be much valuable information and data made common in connection with the use of concrete that may be relied on by the architect, builder, and clerk of works. At present the information available is not altogether of that character. For this reason, treatises on concrete, written only a few years ago even, based principally on theoretical deductions, should be read with caution.

The very simplicity of concrete has led to its abuse, for it has been, and is still, often considered that anything nearest to hand—for instance, pit gravel of any description, broken stone and brickbats mixed with all kinds of rubbish—will do for an aggregate; that the cheapest cement in the market is quite good enough for a matrice; and that the cleanliness of the water requires no consideration—anything will do.

This is altogether wrong.

Labour.—Another factor is the human equation. The cement may be good, the aggregate of a suitable nature and well graded, and the water clean, but if the materials are not thoroughly mixed and the water not suitably proportioned, the value of the concrete is seriously diminished. Machine mixing remedies this to a great extent, but for many building purposes mixing machines do not seem as yet to find much favour. The mixing of concrete is not a favourite occupation with workmen; it is laborious work which can be lessened if the materials are not wrist-turned, but simply lifted in the shovel and deposited close at hand without being turned over.

Suitable Aggregates.—The principal materials more or less adapted for aggregates most of which I have used are granite and other stone quarry chippings, broken brick or tile-yard debris, burnt clay, slag from iron ore, flints, furnace or boiler ashes, coke breeze, and chalk. Chalk would be rarely used in an ordinary way, more especially the top strata, which is soft, porous, and easily affected by frost; but I have used it where it was difficult to obtain any other except from a long distance. For small holdings in chalk districts, no doubt, good substantial dry walls can be made with chalk concrete where better aggregates cannot be obtained.

Coke Breeze.—Coke breeze as an aggregate is thought by many to be beneath notice. It was extensively used for many years, principally for floors, but I submit undeservedly lost its character some time since through a letter in the *Times* telling of its failure in Germany, where it had been prohibited. It was not stated, I believe, of what class of coal it formed the residue, and this is an important point. This letter was followed by others telling how it was of such an inflammable nature that if exposed to a severe fire it was second only to coal in assisting combustion. Another letter stated that it disintegrated in the course of a few years and crumbled away. It was a case of giving a dog a bad name.

So far as its strength is concerned, Mr. Kirkaldy made some experiments for the West Ham Corporation some years since, with the following result: A brick pier, 18 in. square and 18 in. in height, made with best stock bricks and blue lias lime mortar, crushed at the end of two years with 46 tons per sq. ft.; a similar pier of Harold Wood bricks and blue lias lime mortar crushed with 75 tons per sq. ft.; another pier made of 6 parts of coke breeze to 1 part of Portland cement crushed with 131 tons per sq. ft.

As to inflammability, the tests made by the British Fire Prevention Committee with various kinds of floors, each under similar conditions exposed for three hours to an increasing and ultimate temperature of 1,900°F. and water played on them from a hose pipe, gave the following results: Coke breeze and burnt ballast equal and best: each was found, after being allowed to cool, practically free from cracks or deflection; and Thames ballast and granite chips the worst.

I have used some thousands of tons of coke breeze for floors and do not remember a failure of any kind therewith. I am aware that coke breeze is condemned by many as an unsuitable aggregate. I can only speak from my own experience; and although it is not, taken altogether, the best material for floors and roofs, I have found it one of the best.

Ashes.—One of the best aggregates for most purposes is ashes from locomotive boilers. It contains no impurities, is obtainable at most railway stations, and is inexpensive; but one company—the London and South Western—allow their engine-drivers, when passing through a lias limestone district, to use fragments of limestone in the furnaces to economise the coal consumption; it is not very perceptible among the ashes, and does not slake perhaps for some time after the concrete has been in place; but when it does, it entirely ruptures the concrete. I have known floors and stairs to be entirely reconstructed as a result. Where locomotive ashes are employed inquiry should be made relative thereto.

United States Government tests have proved that the carbonate of lime which forms so large a constituent of Portland cement neutralises the effect of sulphur in aggregates to a great extent.

Parts of Aggregates Equivalent to Sand.—It is usual to specify that the sandy and dirty element in some aggregates shall be screened out and replaced by coarse, sharp sand, but I could never understand the object of this. The coarse sandy element of suitable aggregates such as slag, furnace ashes, brick debris or crushed stone chippings is in every way as good as pit or Thames sand, but it is desirable to eliminate the portion below the size of coarse sand, and I assume it is considered impracticable to remove one without the other. But my experience is that it is more economical and effectual to wash out the fine, dirty, and dusty particles and leave in the coarse, sandy ones.

Grading Aggregate.—The size of the aggregate has long been a disputed point, but United States Government tests have confirmed what has always been my practice, namely, that no matter the purpose for which it is used, the coarser the aggregate, provided perfect homogeneity or denseness is secured, the stronger the concrete. The size, however, depends upon the nature of the work. A very coarse aggregate, so that it is graded by intermediate sizes down to that of coarse sand, would be the best for wide and deep foundations, but far too coarse for floors, roofs, walls, or partitions—it depends entirely upon their thickness.

Cleanliness.—The cleanliness of the aggregate is another factor of the greatest importance. Most aggregates are unclean, except, perhaps, river gravel from a quick-running stream. Very few pit gravels are clean, and, as a rule, they are the most difficult to wash ; they are usually mixed with unctuous clay, which is difficult to get rid of and which is injurious to cement. If clean, the particles are usually of a rounded shape, the result of attrition at some former period, and not a desirable one for an aggregate.

It may be thought that quarry waste, brick-yard débris, slag and materials generally that have passed through fire are quite free from deleterious matter, but they are not. If they have passed through fire and been broken by hand or by a stone-crusher, the particles will be found covered with a fine, impalpable dust, almost imperceptible. If washed in a tub, as an experiment, and kept well stirred the water will be found charged to a considerable extent with this dusty element which is injurious to cement. Practically nearly all aggregates are very much improved by washing, which is an economic process if measured by strength.

Mixing Concrete.—The aggregate and matrice should be turned over twice dry and twice while water is being added, and never less ; the more they are mixed the better the concrete, and the more readily the various sized particles find their respective positions in the mass.

For many years it was advocated that only as much water should be used as will coat the aggregate with the cement and render the concrete of a sticky character. Actual practice is convincing enough to prove that this is wrong. The particles of the aggregate do not slide easily into place, and the concrete is not dense. But if the concrete is in a sloppy condition, better homogeneity or denseness is the result. It is almost needless to say that the water used in mixing concrete should be clean ; if otherwise it is equal to using an unclean aggregate.

Plums or Packing.—Packing may be any size so long as it does not reach the vertical faces of foundations or monolithic walls by at least 2 in. and the particles are kept apart at least 2 in., and are well rubbed in the soft mass, not merely laid on the concrete. Obviously the material must be clean.

Concrete Walls.—The disadvantage of building monolithic concrete walls is the cost of the forms or shuttering necessary for forming the troughs in which the concrete is to be deposited. In addition, unless it forms a backing to stone or brickwork, it has to be cemented or rough cast externally, so that the cost is often more than brickwork. For buildings of some magnitude of a plain character, free from irregularities of plan, and of a simple design, such as warehouses, farm buildings, and factories, it can be used in most cases to advantage, so far as regards cost, while it possesses much greater strength and durability and freedom from the necessity of repairs, more so than ordinary brick walls.

With regard to monolithic concrete walls being weatherproof, I have never known an instance of their being otherwise if they were cemented or rough-cast externally.

As a hygienic material concrete is superior to any other. If we go into the rooms of a brick house after they have been shut up for some time there is often a musty smell prevailing. I never found this in a concrete house or cottage after being closed for a time.

The rooms in a well-built concrete house are cooler in summer and warmer in winter than those of a brick house, as concrete walls are more equable in temperature owing to their being non-absorbent and not so readily chilled as brickwork.

The Future of Concrete.—With regard to the future of concrete for buildings and allied purposes in large towns, its present use seems to indicate that it will be confined principally to floors and roofs, and in connection with skeleton steel frame construction and certain purposes for which cement and granite chips can be employed, such as pavings, steps, stairs, sills, lintels, etc. In the country there should be great scope for the use of concrete. Eventually concrete building may be, and should be, a distinct occupation. The walls of factories, workshops, warehouses, and a similar class of buildings where no great architectural efforts are needed, and which are simple in plan and arrangement, can be built at a less cost than with brick or stone, and for farm buildings it is still better adapted, as it is applicable not only to walls, but to pavings for livestock places and for floors, and almost the entire fitments. Mangers, feeding-troughs, water-troughs, tanks for storing rainwater, stable stall divisions, channel gutters, and manure pits are all better executed with concrete than with any other material, and at a less cost.

Buildings of this class are practically free from the farmer's enemies, rats and mice, or can be made so with a little care. Rats, the most cunning of rodents, very much dislike concrete buildings. They can bore their way through a brick wall, but they never attempt to practise on a well-constructed concrete wall.

On hygienic grounds it is superior to most other materials for farm buildings. Healthy surroundings are almost as much a necessity for cattle as for human beings.

For cottages and buildings, for small holdings, it is also well adapted. Where low-lying grasslands and meadows are intersected by running streams there is a necessity for foot-bridges, cattle-bridges, sluices, hatchways, sheepways, etc., and for which there is nothing can compare with concrete for economy of cost and durability.

THE INSTITUTION OF CIVIL ENGINEERS.

MANCHESTER ASSOCIATION OF STUDENTS.

CONCRETE AND REINFORCED CONCRETE PILES.

Paper by HAROLD J F. GOURLEY, B.Eng., Stud.Inst.C.E.

On November 23rd last Mr. H. J. F. Gourley read a paper entitled "Concrete and Reinforced Concrete Piles" before the Manchester Students' Association of the Institution of Civil Engineers. A number of lantern slides were shown, and an interesting discussion followed. We give a summary of the paper below.

Generally.—To obtain timber piles of a uniform quality has been an increasing difficulty. Wooden piles may also be defective though apparently sound, judging by their external appearance. With thorough supervision and the use of properly graded materials there should not be any difficulty in securing perfect uniformity and soundness in concrete and reinforced concrete piles.

The load placed upon an average wooden pile may be taken at, say, 15 tons, whilst on concrete piles an average load is 40 tons or more, depending on the particular type of pile adopted.

The wooden pile must always be wet. If this condition obtains, the life of the pile is long; should the pile, however, be subjected to the partial wet and dry state, deterioration soon sets in, and its life is very short. Cases have occurred where wooden piles have been driven with the entire length of the pile below the water level, and in which the piles have been exposed to the danger of the dry condition owing to a subsequent lowering of the water level. There is no such risk where concrete piles are used, nor is it necessary to drive the piles so as to be below the water level. Since the timber piling cannot stand above the water level, the trench for the foundation must be carried down to this level, and must be wider than is required for the concrete pile foundation, since the wooden piles can carry so much less than the concrete, and must therefore be more numerous. If one takes into consideration the extra depth and width of trench, together with the cost of timber sheeting and possibly pumping, it is evident that in this case a considerable saving follows the use of concrete piles. The saving, of course, depends on the depth of the ground water surface below the ground level.

Reinforced Concrete Piles for Marine Work.—For marine work reinforced concrete piles offer certain advantages. They compare favourably with timber as regards cost, and they are immune from the ravages of the *teredo navalis*, which is a decided advantage in many cases. Up to now no really satisfactory method of laterally bracing jetties constructed of reinforced concrete has been found—the difficulty being that braces cannot be moulded under water, and even if they are moulded ashore no suitable means of connection to the vertical piles has been devised. It is not known, either, whether the shocks during the driving of reinforced piles cause hair cracks, through which moisture can penetrate, or not. If such cracks are formed they may in time lead to serious disintegration, and this is a point which it would appear desirable to investigate before expressing entire satisfaction with reinforced concrete piles for such work.

Concrete piles may be divided into two classes according as they are cast in place or cast in moulds, and are driven much in the same way as timber piles.

" Cast-in-place " piles are generally, though not necessarily, without reinforcement, and the pile hole is made artificially and afterwards filled with concrete.

" Cast-and-driven " piles are always reinforced to enable them to withstand successfully the tensile and shear stresses due to handling and driving. The risk of damage during the driving of such piles is much reduced in most cases by making free use of the water jet, and in others by using a special driving cap to protect the head of the pile.

"CAST-IN-PLACE" PILES.

"Compressol" Piles.—In the " Compressol " System, a hole is formed in the ground by dropping a conical " perforator," about 10 ft. long, 3 ft. dia. at its upper end, and weighing 2 tons, from a height varying from 30 to 50 ft. In addition to forming the hole this operation causes a considerable compression and consolidation of the strata. The top of the perforator is provided with a cutting edge, which clears the cavity when the die is hauled up by the winch after each drop. A poor concrete—about 10 to 1—is deposited in 12-in. layers, each layer being thoroughly rammed by a 2-ton rammer, which is so formed as to drive the concrete laterally into the strata surrounding the well made by the perforator. The size of the finished pile depends on the nature of the strata passed through, the concrete naturally spreading more in soft than in hard strata.

Some of the advantages claimed for this system are, briefly : Continuity of section from top to bottom is ensured, and the danger of admixture of concrete and surrounding strata is largely obviated. In any case the great section (4 to 6 ft. dia.) provides an ample margin for such contingencies. Comparing the corrugated surface of the piles, due to differences in the strata passed through, with the plane surfaces of other piles, one sees what a large amount of skin friction, which adds greatly to the bearing capacity of the pile, is provided. The disturbance caused in the vicinity during the whole operation is very slight, and this makes the use of " Compressol " possible when ordinary pile driving would be out of the question.

"Simplex" Piles.—In the " Simplex " method of constructing foundations a hollow cylinder is driven to a firm bearing ; this cylinder is gradually withdrawn and the hole made good with concrete rammed with a heavy hammer.

The cylinder or former is of $\frac{3}{4}$ in. or $\frac{7}{8}$ in. lap-welded steel, generally 16 in. dia., and from 30 to 40 ft. in length, made up of two or three lengths cross welded. The upper part is strengthened to withstand the impact of the hammer by a $\frac{7}{8}$-in. riveted band, 18 in. deep ; and a narrower band, $\frac{1}{2}$ in. thick, is riveted to the lower end above the shoe.

The hinged jaws, or alligator point, are toothed so that when closed they form a conical driving point ; and when open, during the withdrawal of the former, they form part of a cylinder of the same section as the lower part of the cylinder, and thus will lie close to the sides of the hole and leave an unobstructed passage for the concrete from top to bottom of the cylinder.

As the diameter just above the alligator point is rather greater than that of the body, the frictional resistance at withdrawal is reduced considerably.

The cylinder is sunk into the ground by a pile driver, which differs but little from the ordinary type. The driving cap is a steel casting having a socket at the bottom, which fits into the head of the former, and the head of the pile is kept in position by making this cap slide between channel irons. A hardwood plug, 15 in. dia., fits into the top of the driving cap, and projects a few inches to receive the blows of the cast-iron hammer, which weighs 30 cwts., and falls 6 to 10 ft.

When the cylinder has reached the required depth it is filled in one of two ways. The simplest is to fill the tube up with concrete to a height of several feet above the level of the finished head of the pile, to allow for its settling as the cylinder is withdrawn. The pulling tackle is then attached and the former gradually withdrawn, the concrete at the same time sinking, expanding, and filling the hole left by the former. As the tube comes up, a thin film of water forms on the inside, and this reduces the friction. The pulling up, by causing a turning-over action in the particles forming the aggregate, tends to form a denser mixture. On the other hand, it would appear that the surface of the finished pile is smooth as compared with the surface obtained by the second method.

The other way of filling is to put in about 3 ft. of concrete and then raise the cylinder 2 ft. This concrete is then rammed by a 300-lb. hammer, and a further 3 ft. of concrete is added. The cylinder is raised 2 ft., and the material again rammed. Proceeding in this way, the hole made by the cylinder is filled, and should the material about the pile be soft, it is quite likely that the diameter of the pile will exceed that of the cylinder.

The " Simplex " pile has the advantage that no preliminary boring on a site to be piled is required, and there is no waste caused by cutting off, or extra cost due to splicing. Its bearing capacity is determined either by the final set of the former or by loading a trial pile.

"Raymond" Piles.—This pile is usually placed by the pile core method, which may be briefly described as follows : A collapsible steel pile core of the desired size and shape is encased in a thin closely fitting sheet steel shell. This core and shell are driven to the required depth by means of a pile driver, frequently fitted with a steam hammer. The core is so constructed that when the driving is finished it can be collapsed, losing contact with the shell, so that it is easily withdrawn, leaving the shell or casing to act as a mould for the concrete.

When the core is withdrawn the shell is filled with a well-mixed concrete—usually 8 to 1—carefully tamped during the filling process. Before the concrete is put in, the interior of the shell may be inspected by lowering an electric light into it, or by reflecting sunlight by means of a mirror, so that perfection of shape is assured. Of course, in this pile there is no danger of admixture of earth or of a weakening of the concrete due to the character of the strata passed through, but we do not get a corrugated surface such as is obtained where a shell is not used. It is known that iron is preserved in certain kinds of material, but in others it rapidly corrodes. Such an effect in the case of the shell may allow a small—since the shell is thin—settlement in the pile some time after it has been driven, and this settlement may have serious results in the superstructure.

" Raymond " piles have a large taper—a 30 ft. pile would be 20 ins. diameter at the top and 8 ins. at the bottom—and this appears, from numerous tests which have been made, to give them a high carrying capacity, evidently owing to the fact that in the case of a tapered pile the load is more uniformly distributed throughout its entire length, whilst in a straight pile the load is largely concentrated on the limited area of the point. As regards their carrying capacity, this is usually determined by a trial pile, but has been found from the final set of the shell ; a 22 ft. pile driven in sand and clay to a soft bottom carried over 60 tons with a very slight settlement.

"CAST-AND-DRIVEN" PILES.

Strong timber moulds are constructed of the length, size, and shape of the proposed pile, one side being left open and gradually closed as the concrete is filled in.

In vertically moulded piles the reinforcement is placed in its proper position, the lower ends of the bars being bent inwards towards the metal shoe, if such be used, or to form the shoe. The metal shoe is firmly attached to the pile concrete by wrought-iron straps. The connecting pieces and stirrups are dropped over the top and fixed in their places opposite gauge marks on the edge of the mould, the distance apart of these connectors varying from 2 ins. at the top and bottom to 10 ins. at the centre. The faces of the mould are well soaped, to prevent the cement sticking to them, before the filling in begins. The concrete is put in in small quantities and well rammed around the reinforcement, the open side being closed by battens 4 ins. wide fitting into grooves in the casing as the filling proceeds.

Horizontal moulding is done in much the same manner, except that in this case it is not necessary to close in the fourth side, though a light covering may prevent accidental damage to the green pile.

The pile is left in the mould for a couple of days, and then for a month or more, according as it is summer or winter, it is kept in a moist state, and at the end of this period it is matured and ready for driving.

It is most essential that the point of the shoe should lie in the axis of the pile, and that the bevels of the toe should be equal, otherwise great difficulty will be experienced in getting the pile to drive truly. As the cutting off of reinforced piles is a difficult and expensive job, it is important that the lengths of the various piles should be known with certainty.

The "Hennebique" Pile.—In the " Hennebique " pile the longitudinal reinforcement consists of round bars varying in diameter from 1 in. to 1⅝ in., one being placed near each corner of the rectangular pile, wired together with $\frac{3}{16}$ in. wire stirrups and distance pieces to prevent the bars spreading under a vertical load. The toe is pyramidal in shape, shod with a cast-iron shoe secured to the pile by wrought-iron straps. The head of the pile is circular—the bars being bent inwards—to receive the cap used in driving. Frequently the longitudinal bars are allowed to project above the concrete head of the pile to facilitate the subsequent joining up with the superstructure ; the form of the cushion head, of course, allows of this being done.

To be prepared for hard driving, all moulded piles should be provided with a pipe down the centre to permit of water pressure being used. The pipe leaves the pile at a distance of about 3 ft. down from the top end, this being done to avoid damage to the pipe in driving, and also in order that a flexible pipe connection can be made so that the water-jet can be applied to the point of the pile simultaneously with the driving operations.

A water jet greatly assists the driving of a pile—firstly, because the water returning along the sides of the pile reduces the frictional resistance to its motion ; and, secondly, by softening and scouring out the material immediately underneath the pile is enabled to penetrate more easily.

The "Gilbreth" Corrugated Pile.—The "Gilbreth" corrugated pile is much used in the United States, and possesses one or two features which merit a little consideration. In the section there is a series of exterior longitudinal grooves which extend for nearly the whole length of the pile, and an axial tapered hole is arranged.

Compared weight for weight with a solid smooth reinforced pile, the "Gilbreth" would appear to be quite as strong, if not stronger, and the increased perimeter considerably increases the area in contact with the surrounding soil, and hence the bearing capacity of the pile. It is most frequently driven by the water jet, and the external grooves serve as channels for the return of the water and the material carried up with it. As a rule, the water jet is withdrawn from use when the last foot of penetration is to be accomplished, and monkey driving is then used to ensure that the necessary bearing power has been obtained.

The "Considère" Spirally Armoured Pile.—In the "Considère" Spirally armoured pile the chief feature is the spiral armouring which is used to prevent the lateral bulging of the concrete, without which crushing cannot ensue. "Considère" claims that the experiments carried out by the French Commission on Reinforced Concrete show that spirally armoured columns are at least two and a half times as strong as similar columns having the same percentage of metal disposed in the form of longitudinal bars and lateral ties. Quite apart from the question of strength, the spiral armouring appears to be of great value, in that it allows the pile to be driven with a minimum of damage to the concrete mass.

For piles of this type up to 45 ft. in length, and, say, 14 ins. dia., the spiral is $\frac{3}{8}$ in. dia. steel wound to a dia. of $11\frac{1}{2}$ ins., with a pitch varying from $1\frac{1}{2}$ to 2 ins., and the eight longitudinal steel rods would be $\frac{5}{8}$ to $\frac{3}{4}$ in. dia. The shoe consists of a steel casting. The spiral armouring is increased in diameter and diminished in pitch at the extremities of the pile. The concrete used is a rich mixture—about 3 to 1—and the minimum period allowed for maturing is six weeks. Whether a steam or an ordinary pile driver is used, the monkey is allowed to fall directly upon the head of the pile without the intervention of a cushion or dolly of any kind, and even in hard driving it has been found that the damage to the head has not extended more than a few inches down.

Since it appears * that the compressive strength of concrete increases with the weight of the concrete, the proportion of cement to the other materials remaining constant, a mixture of the maximum density should be aimed at. The aggregate, frequently of ballast, though preferably of broken granite or other dense material, should be graded from 1 in. to $\frac{1}{8}$ in., and with only as much sand added as is necessary to fill the voids in the coarse material. The concrete should be mixed rather wet, and well worked in and about the reinforcement, which, particularly for marine work, should have at least $1\frac{1}{2}$ ins. cover ; and to ensure a uniform set of the concrete throughout the section of the pile and the minimum time for maturing, a slow-setting cement is to be preferred.

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* Taylor & Thompson, "Concrete, Plain and Reinforced," p. 391 ; Prel. and Interim Report, Committee on Reinforced Concrete, Inst.C.E., pp. 196, 197.

NEW WORKS IN CONCRETE
AT HOME AND ABROAD.

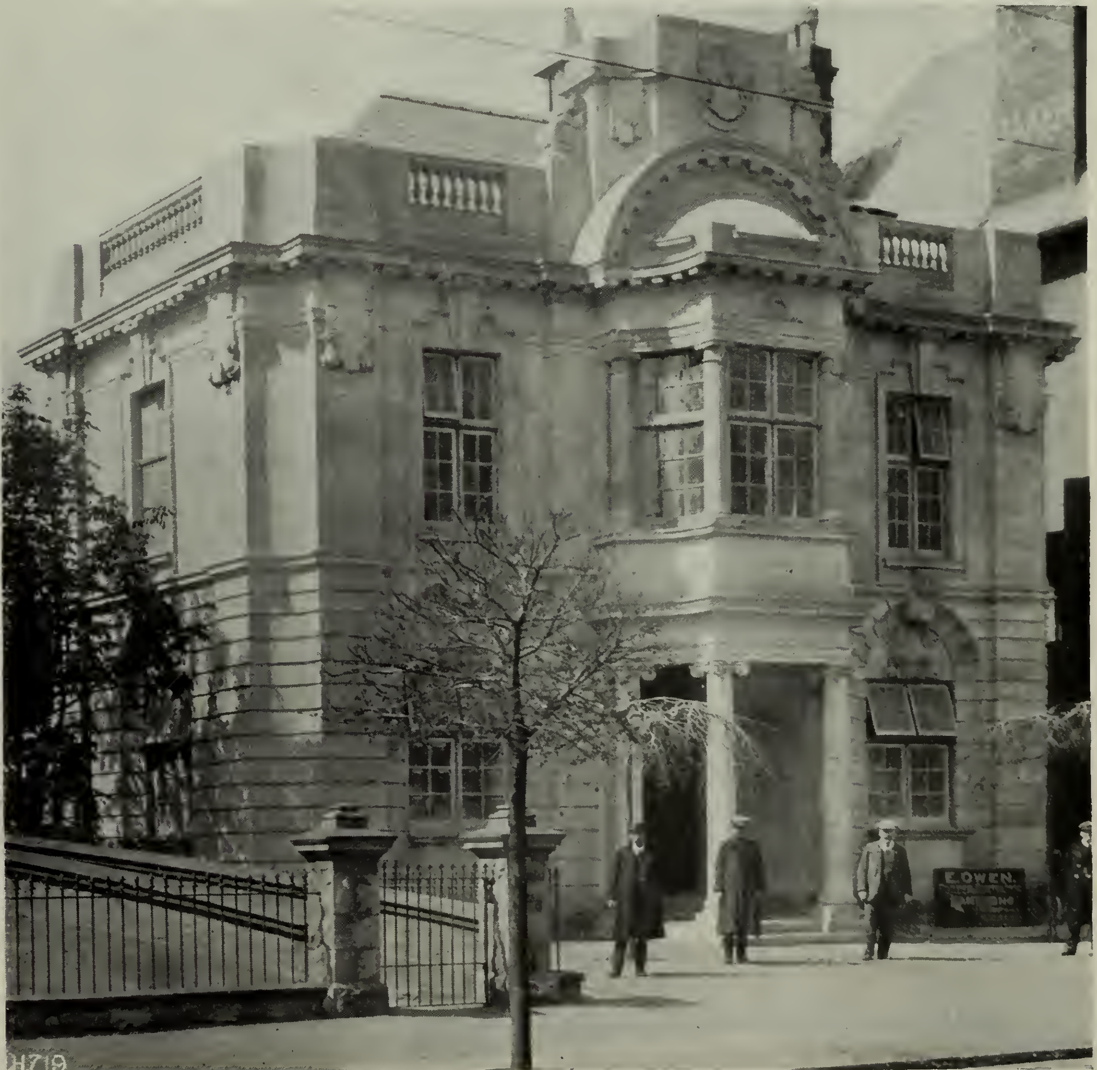
Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

CARNEGIE LIBRARY, LLANDUDNO.

THE building described below is probably one of the first libraries in which reinforced concrete has been adopted to any extent. It is situated in Mostyn Street, Llandudno, the main thoroughfare of the seaside resort in North Wales.

The architect, Mr. G. A. Humphreys, F.R.I.B.A., of Llandudno, originally intended using ordinary steel construction for the main structural portion of the work, but owing to the economy attainable by the use of reinforced concrete, and what is very important in a public building—viz., fireproof construction, he decided in favour of the latter.

Reinforced concrete was adopted for the floors, staircase, dome, flats, gallery and columns.



View of finished building.
CARNEGIE LIBRARY, LLANDUDNO.

The floors were designed to carry a safe load of 1½ cwts. per sq. ft. From the drawings it will be seen that the walls of the original building which stood on the site have been used for supporting the ground floor, the slab being 4 in. in thickness and

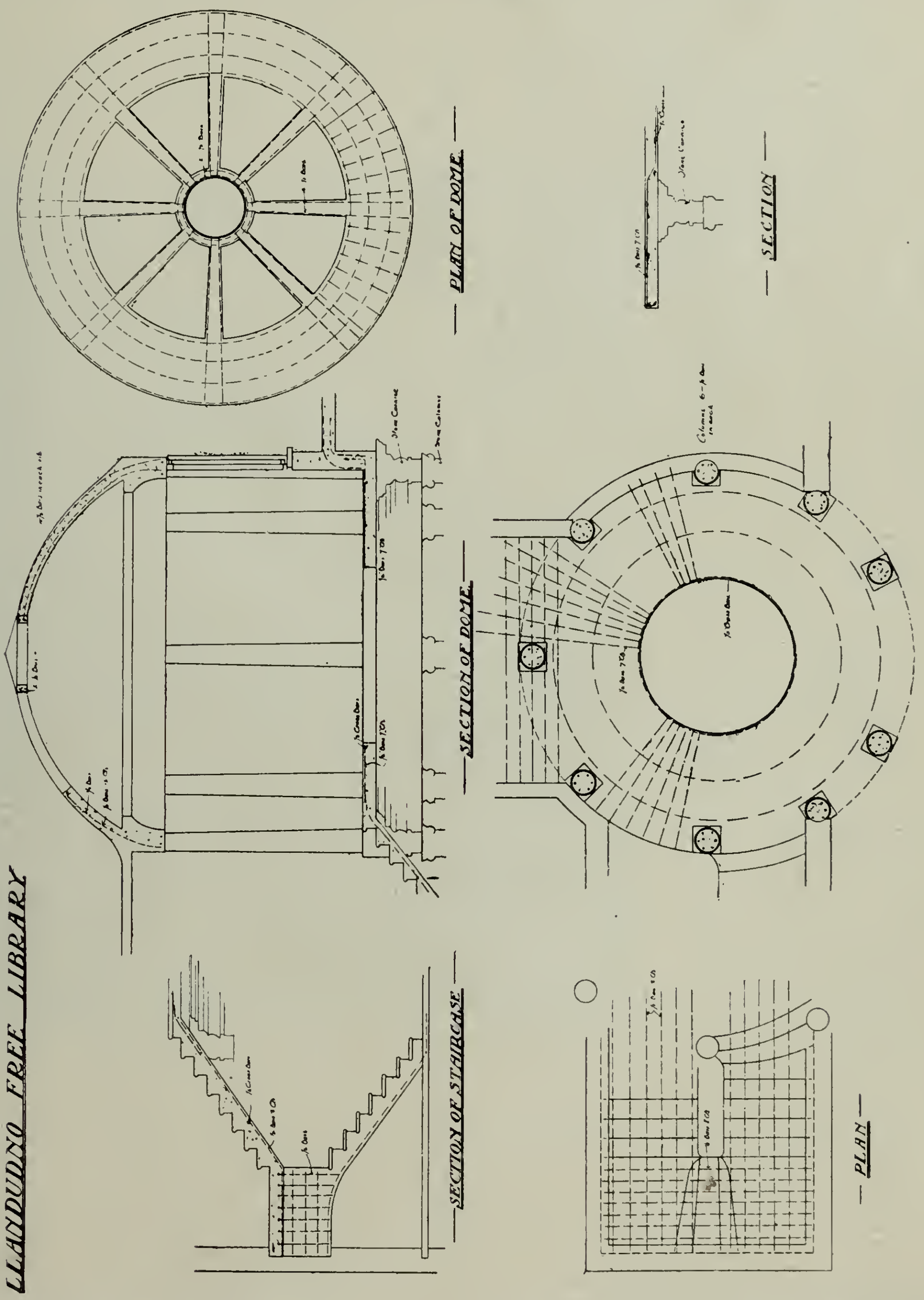
View of staircase and gallery.
CARNEGIE LIBRARY, LLANDUDNO.

reinforced with ⅓-in. bars, ½-in. cover being allowed for reinforcement, the surface of the floor being prepared for wood blocks. The first floors are suported on reinforced concrete beams, ¾-in. bars being the chief reinforcement, the bars being turned up at the end for shear.

As it was necessary to obtain top lights for some of the rooms, lantern lights were used, supported by flats, the beams being so arranged to support the lantern lights ; a 12 in. by 6 in. parapet wall being built round lantern well, into which bolts were sunk to receive lantern lights.

All flats were asphalted to give a thoroughly watertight finish.

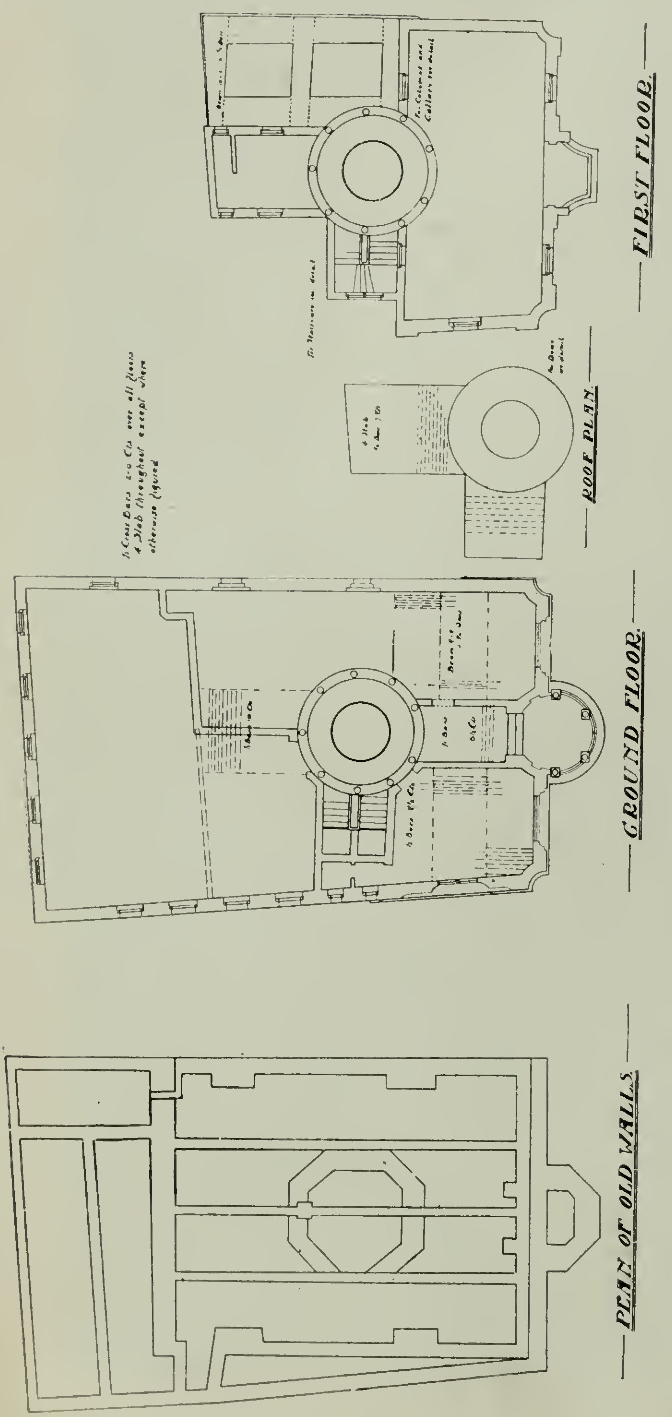
The staircase was built of concrete *in situ*. As will be seen from the drawings, this consists of two flights of steps leading from the ground floor to the gallery on the first floor, which gives access to the rooms on this floor. The staircase is so designed to be self-supporting ; the main reinforcement, as will be seen from the drawings, runs longitudinally, with cross bars at 2 ft. centres, the whole being finished in granolithic, with mouldings planted on.



Details of reinforced concrete work.
Carnegie Library, Llandudno.

As mentioned, the staircase lands on a gallery, which is in the form of a cantilever, anchorage being obtained as shown on the drawings. Reinforced concrete columns rise from the gallery supporting the dome, which gives light to staircase and portion of the ground floor.

The dome is 18 ft. in diameter and rises solidly for about half its height, the remainder being used for lighting purposes. It springs from a circular beam supported by columns; the main reinforcement being $\frac{5}{8}$-in. bars, anchored into the circular beams. The top portion of the dome is divided into eight parts by ribs, tapering to a circular ring at the top; the reinforcement for the ribs being four $\frac{1}{3}$-in. bars hooked round two $\frac{1}{3}$-in. bars in the circular ring. The whole gives a very light and pleasing effect, which would have been impossible to attain with ordinary steel construction. The reinforced concrete work was carried out by Messrs. Henry Johnson & Sons, of Fontenoy Street, Liverpool; The Patent Indented Steel Bar Co., of Westminster, S.W., supplying the reinforcing steel; Mr. J. Parr Emett, 48 Castle Street, Liverpool, being the consulting engineer.



Carnegie Library, Llandudno.

REINFORCED CONCRETE STORES AT CHELSEA FOR MESSRS. WHITBREAD & CO., LTD.

This building is constructed throughout of reinforced concrete, with the exception of the external walls, which are in brick, and it occupies an area of about 7,900 sq. ft. There are four floors in all, including a basement storey, and, on account of the use for which it is intended, the loads calculated to come upon the floors were somewhat heavy; and provision had to be made for a cartway and loading stage over the basement floor. The ground floor is used as a filling room, the first floor as a stacking room, and the second floor as a washing room.

The columns of reinforced concrete are spaced at 10 ft. centres in the direction of the length of the building and at about 19 ft. 6 in. centres across the width of the building, as will be seen on the first floor plan which is illustrated on page 65. The main floor beams run across the width of the building between the columns with a span of about 19 ft. 6 in., with secondary beams at right angles spaced about 6 ft. apart. The loads allowed on each floor were as follows: Ground floor, 5 cwt. per ft.

super ; first floor, 4 cwt. ; and second floor, 3 cwt. The external brick walls actually carry the outer edges of the floors, although the front wall itself is carried, at the first floor level, on a reinforced concrete beam continuous throughout its length, with reinforced concrete columns at intervals, as shown. Where the main concrete floor beams rest on the wall, continuous reinforced templates were introduced to distribute the weight over the whole pier. The columns are octagonal on plan with an over-all size of 18 in., reinforced with 1-in. and $\frac{7}{8}$-in. cup bars with wiring as necessary.

The foundations to the columns were constructed on the continuous principle, with concrete 6 ft. wide extending through the whole length of the building. These slabs were 2 ft. thick and reinforced with $\frac{5}{8}$-in. cup bars at 12-in. and 18-in. centres across the width, with similar bars in the direction of the length, and three $\frac{3}{4}$-in. Kahn trussed bars were introduced between the columns in the upper surface to resist the negative bending moment which occurs in that portion.

Reinforced Concrete Stores at Chelsea.

Generally speaking, the main floor beams were 12 in. wide and 15 in. deep below the slabs, reinforced with three cup bars and three Kahn trussed bars ; while the secondary beams were 5 in. wide and 9 in. deep below the slabs, reinforced with one cup bar and one Kahn trussed bar.

The floor slabs varied in thickness from 5 to 7 in., and generally were reinforced with $\frac{5}{8}$-in. cup bars at 6-in. centres, and to prevent cracks in the slabs over the main beams $\frac{7}{8}$-in. bars 5 ft. long were provided at 12 in. centres.

The pits which were required for lifts, etc., were constructed of 6 in. of reinforced concrete suspended from the floor construction above, and a finished view of one of these pits can be seen in the illustration on page 66, which shows an interior view of a portion of the basement.

A good idea of the finished construction, showing the columns, main beams and secondary beams, will also be seen on page 66.

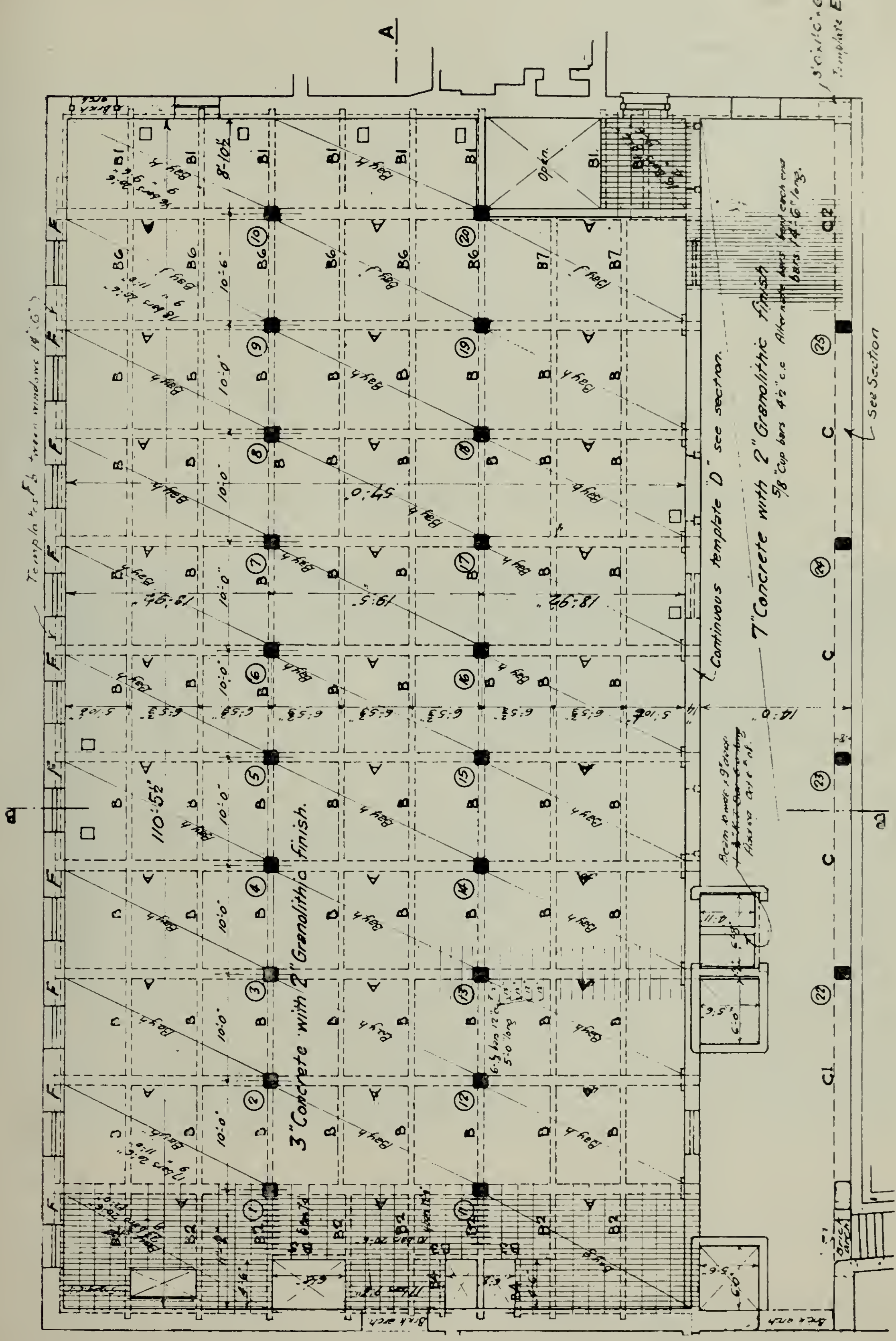
All the concrete on the second floor had to be laid to falls, and a gutter formed in the centre to carry off the water during washing. The soffites of all the main and secondary beams were kept at the same level, and the fall obtained by varying the depths of the beams.

The reinforcement used throughout consisted of cup bars and Kahn trussed bars, which were required to be of a tensile strength equal to the British standard specification for mild steel.

The whole of the concrete was mixed by hand, the aggregate being $\frac{3}{4}$-in. crushed ballast and clean, sharp sand, and the cement was Portland of the standard

Views of interior of building.
Reinforced Concrete Stores at Chelsea.

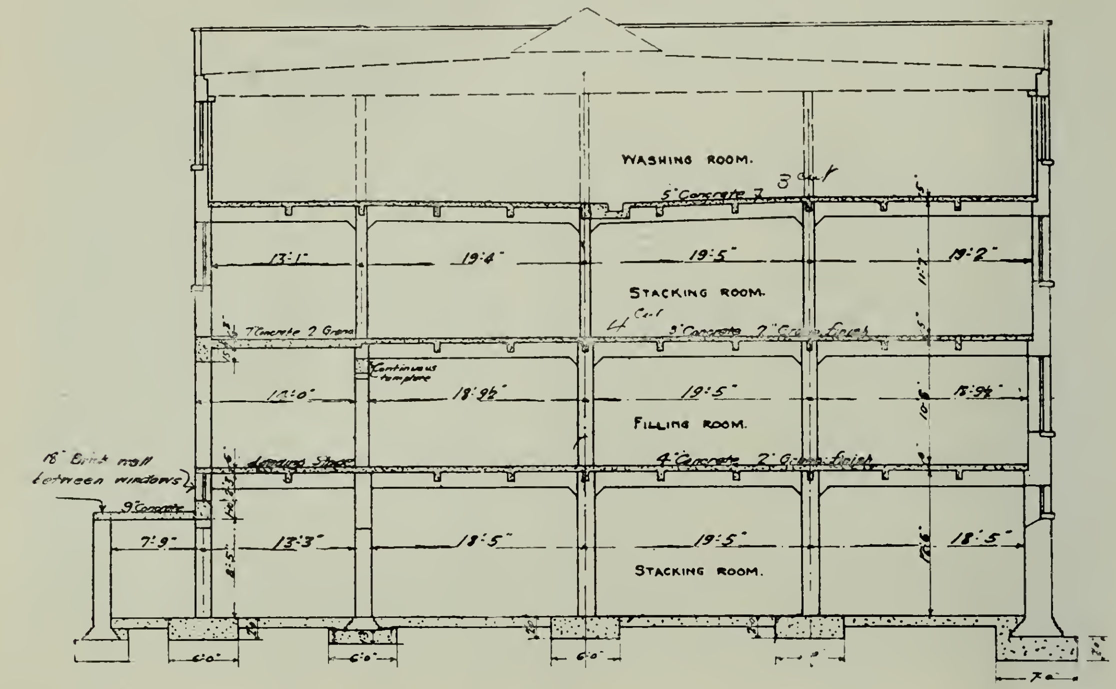
required by the British specification. The proportions for the columns and


A
Open
3" Concrete with 2" Granolithic finish.
7" Concrete with 2" Granolithic finish
Continuous template "D" see section.
See Section
B1
B6
B7
B
B2
C
C1
C2
110'-5½"
57'-0"
10'-0"

Plan of first floor beams.
Reinforced Concrete Stores at Chelsea.

beams supporting the wall were 27 cu. ft. ballast, 13½ cu. ft. sand, and 6⅓ cwt cement, while for the beams and floor slabs the mixture was 27 cu. ft. ballast, 13½ cu. ft. sand, and 5 cwt. cement.

The architect for this building was Mr. A. Dixon, and the whole of the concrete work was designed and executed by Messrs. The Cubitt Concrete Construction Co., of 260 Gray's Inn Road, W.C.



Cross section.
Reinforced Concrete Stores at Chelsea.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

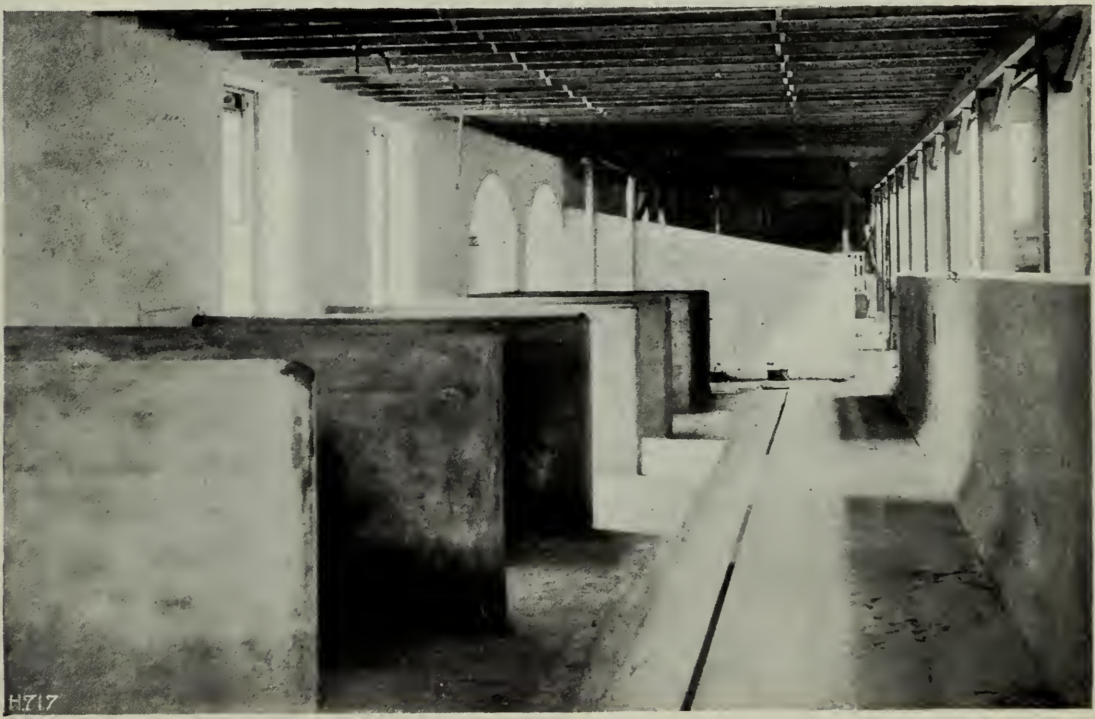
Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE COW-STALLS.

We have given numerous examples from time to time of the use of cement in farm buildings, pointing out their advantages from a sanitary point of view. The fireproof and permanent qualities of this form of construction, as well as the ease with which concrete floors and walls can be kept clean, are also valuable arguments for its increased use for cow-stalls, stables, piggeries, etc.

The production of clean milk requires the most sanitary conditions in the buildings where it is produced, and in America the Health Departments generally specify that cement must be used for floors in cow-stalls, and that the walls and ceilings must be free from dust-catching surfaces.

The accompanying illustration shows a reinforced concrete dairy cow-stall erected by Mr. Fred Ballard on his model farm at Winnings, Colwall, Malvern.



Cow-stalls, mangers and floor of reinforced concrete.

Reinforced Concrete Dairy Cow-stalls, Winnings Farm, Malvern.

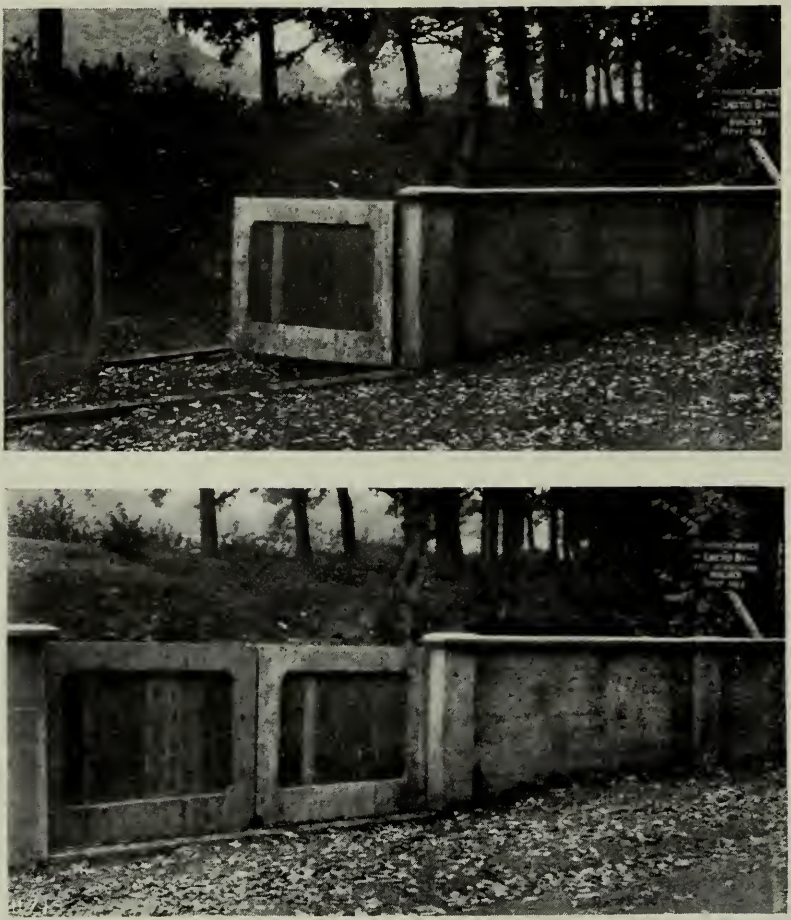
☞ All wood has been eliminated in these stalls, and they have proved most satisfactory owing to their cleanliness and sanitary condition, and have been highly approved of by the local sanitary authorities.

REINFORCED CONCRETE GATE AND WALL.

On the next page we show photographs of a reinforced concrete gate and wall erected by Mr. Charles Hummerstone, builder, of West Mill, Buntingford, Herts.

The wall is 4 ft. high, and cost about 10s. per yd., the cost of the gate being less than if made of wood. They have proved most practical and so satisfactory in every respect that the builder is now using reinforced concrete wherever possible for farm buildings and other work.

Increased use is being made of concrete for fence posts and gates, as it has all the advantages of wooden structures without any of their disadvantages. Concrete posts are not affected by the weather, and require no maintenance charges whatever. After three or four years' use wooden posts deteriorate very greatly in value and lose a great deal of their strength, whereas concrete grows stronger with age.



Reinforced Concrete Gate and Wall at Buntingford, Herts.

ENQUIRY COLUMN.

The name and address of enquirers must always be given, not necessarily for publication.

The advice given in reply to enquiries is a matter of personal opinion, and although contributed in most cases by experts with special knowledge of the matter in question, it must not be considered in the same light as if obtained from a Consulting Engineer or Solicitor, who should always be referred to in important cases, as our columns are not intended to do away with the services of the professional experts on constructional or legal matters.

Replies will be sent by post if the enquiries are marked "Answers by Post" on the outside, and such must be accompanied by a postal order for 1s., made payable to "Concrete and Constructional Engineering." All other enquiries will be replied to in this column.—ED.

CEMENT FOR REINFORCED CONCRETE.

E. J. (The Hague) writes: "Can you tell me whether the kind of cement known in Germany as 'Eisenportland Cement,' containing 70 per cent. real Portland cement and 30 per cent. slag, is good for reinforced concrete work?"

—Cement containing 30 per cent. of slag is not considered suitable for reinforced concrete work owing to the presence of calcium sulphide, which slag cement contains. This substance, in contact with moisture, is liable to decompose and corrode the steel reinforcing bars. For reinforced concrete work nothing but the very finest genuine Portland cement should be used.

MATERIALS FOR CONCRETE.

C. A. (Derby) writes: "Regarding the tables of quantities of materials for floors, etc., in 'Every day Uses of Portland Cement,' advertised in your columns, it is estimated that something like 1·56 cu. yds. of dry materials are required to make 1 cu. yd. of concrete. May I ask if these figures are the result of experiments or merely theoretical calculations, based upon the theory that in the average concrete in place there are no voids whatever?

"If such a large quantity is required, I fail to understand how contractors price concrete 4 : 2 : 1, using Thames ballast, turned four times, etc., at 15s. and less per cu. yd., and make a profit. As the majority of our estimates for concrete work are in districts where the aggregate is of an uncertain character, we are anxious to strike a happy medium between the so many accurate (?) tables published, and thus be somewhat reliable. My practice is to assume $1\frac{1}{5}$ cu. yds. of Thames ballast for 1 cu. yd. of concrete, and, say, about $1\frac{1}{3}$ for an aggregate consisting of broken stone or screened ballast."

—The data for proportioning concrete are quite correct for broken stone concrete, but the quantities must be slightly varied for gravel concrete, being then for a 1 : 2 : 4 mixture 508 lbs. cement = 0·21 cu. yd., 0·42 cu. yd. sand, and 0·83 cu. yd. gravel; total, 1·46 cu. yds. These figures are the results of careful experiments.

The Thames ballast concrete referred to is not proportioned 1 : 2 : 4, but 1 : 4, and the ballast has none of the same sand sifted out, so that the voids in the gravel are filled, and there is practically no shrinkage in bulk on admixture of cement, which merely goes to fill some of the voids in the sand. There is, however, too much sand in unsifted Thames ballast, and the resulting concrete is poor, the voids not being filled in a 1 : 4 mixture, as there is insufficient cement for the purpose. The effect of an excess of sand is explained in the book.

It can well be seen how London contractors can make a profit at 15s. a cu. yd., their working up being something like this:

	s.	d.
4 yds. Thames ballast at 6/6	26	0
1 ton Portland Cement at 21/-	21	0
Making 4 yds. Concrete	47	0
Dividing to bring to 1 yd.	11·75	
Labour at 2/- per yd....	2·00	
	13·75	
Profit, 10 °/ₒ	1·375	
	15·125	

CEMENT AND TAR FOR PRESERVATION OF STEEL.

Can any of our readers give us information as to a mixture of tar and cement used for preserving steel ?

FACTOR OF SAFETY.

F. C. (Belfast) enquires as follows : " As I have not been able to ascertain from any of our text-books on reinforced concrete the full explanation of ' Factor of Safety,' I should be much obliged if you could put me on the road to get the following information :

" A floor is designed to carry a superimposed load of 1½ cwts. per ft. super, and the dead weight of the floor is, say, 90 lbs. per F.S. What is the weight to be applied to get a factor of safety of 4 ?

" Also, what is the strength of a floor composed as follows : 6 ins. of concrete (6–1) in which are embedded T.S.J. 6 by 3 by 12 lbs. over main girders at 11 ft. 6 in. centres. The 6 by 3 R.S.J. being spaced 2 ft. 6 in. centres."

—The factor of safety of a structure is usually defined as the ratio of the load at which the structure would fail, to the working load.

The working load carried by the floor in question, including its own weight, is 1½ cwts. + 90 lbs.—*i.e.*, 258 lbs. per sq. ft. To obtain a factor of safety of 4, the breaking load should therefore be 4 by 258—*i.e.*, 1,032 lbs. per sq. ft. If, however, it is desired that the structure should fail when it is only called upon to support its own weight + 4 times the specified working load, the breaking load would be 90 + 4 × 156—*i.e.*, 714 lbs. per sq. ft. In this case the factor of safety would have been taken on the superimposed load only.

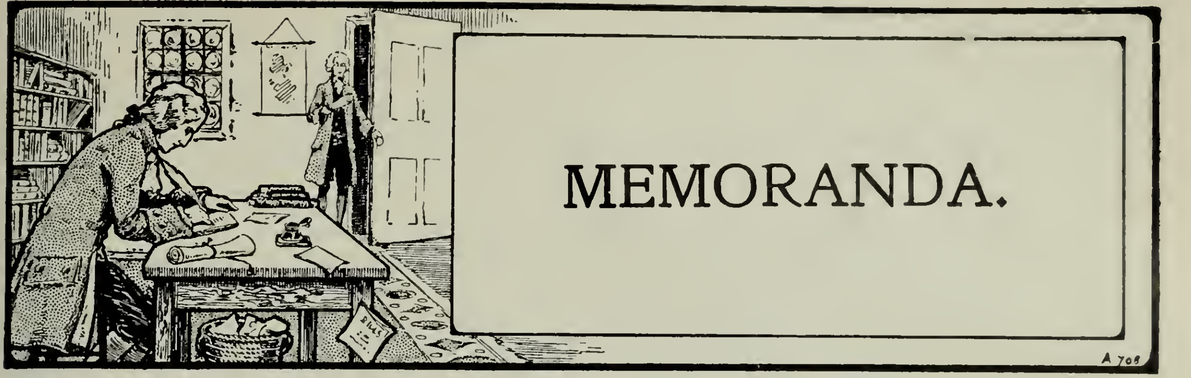
Another method of treating the matter is to design the structure so that the working load shall only cause stresses which bear a certain proportion to the breaking stresses of the steel and concrete respectively. In this case if a factor of safety of 4 is required, the working stress in each material would be calculated to be ¼ of its breaking strength, say, 16,000 lbs. per sq. in. in the steel, if mild steel is used, and, say, 600 lbs. per sq. in. in the concrete in the case of concrete which has a crushing strength of 2,400 lbs. per sq. in.

For reinforced concrete work it is, however, more usual to base the working stress of the steel on its yield point rather than on its breaking strength ; and a factor of safety of 2 on the yield point is more satisfactory than a factor of safety of 4 on the breaking strength. The factor of safety on the concrete is not, of course, affected by this.

Strength of the Floor described.—It appears from the steelwork tables that the load which can be safely carried by a 6 in. by 3 in. by 12 lbs. R.S.J., with a factor of safety of 4 on a span of 11 ft. 6 in., is 3 tons distributed.

The area of floor carried by each joist is 2 ft. 6 in. by 11 ft. 6 in.—*i.e.*, 28¾ sq. ft.

The load per sq. ft. is therefore just over 2 cwt. But the concrete between the joists will carry a far greater load than this, as each panel will to some extent act as an arch spanning between two consecutive joists. It is, therefore, the strength of the joists which is the determining factor in arriving at the strength of the floor. But the strength above given will be increased to a very slight extent by the fact that the joists have concrete on each side of them, though as the top flange of each joist has no definite attachment to the concrete the effect will not be great. We may assume, therefore, that the joists will safely carry 2½ cwts. per sq. ft., and that after deducting the dead load of the concrete, the safe superimposed working load will be 280 – 90—*i.e.*, 190 lbs. per sq. ft.



Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Concrete for the Jewel Room in the Tower of London.—From a national point of view, although the work is itself quite small, one of the most important applications of reinforced concrete has been recently carried out in connection with the Jewel Room in the Tower of London. It has been necessary to render this room both fire and burglar resisting, and in order to effect this the floor has been entirely removed and replaced with concrete 6 in. thick, reinforced on the Kahn system, having ½-in. rib bars centrally placed within its thickness, as a network, running across it in two directions at right angles to one another. The room is an almost perfect octagon, and the floor is 28 ft. across ; but none of the bars exceed 15 ft. in length, being arranged so as to pass or overlap near the centre of the span, the overlapping being arranged in a diagonal pattern on plan near the angles. The floor of the entrance is similarly reinforced, and so are the floors of the trumpet-case and the other recesses, the backs of which are further strengthened with reinforced concrete walls 12 in. thick. These also have a network of ½-in. rib bars in the centre of their thickness, placed at 6-in. centres both vertically and horizontally ; and the spandrel over the entrance doorway is similarly treated, in addition to the old filling of masonry. —*The Building News.*

Concrete as Reinforcement.—An interesting instance of the employment of concrete in engineering structures was exemplified in its use to strengthen the wrought-iron trestle approaches to the railway bridge at Danville, Ill., and also the St. Charles Bridge. These structures, which were built many years ago, were constructed of Phœnix columns with diagonal tie-rods, and with the great increase in train weight that has come about in recent years, it became necessary either to strengthen the trestles or to remove them. The former course was followed, and the columns were encased in concrete. Tests of the compression members show that the addition of the concrete has increased their strength by fully 50 per cent.—*Times Engineering Supplement.*

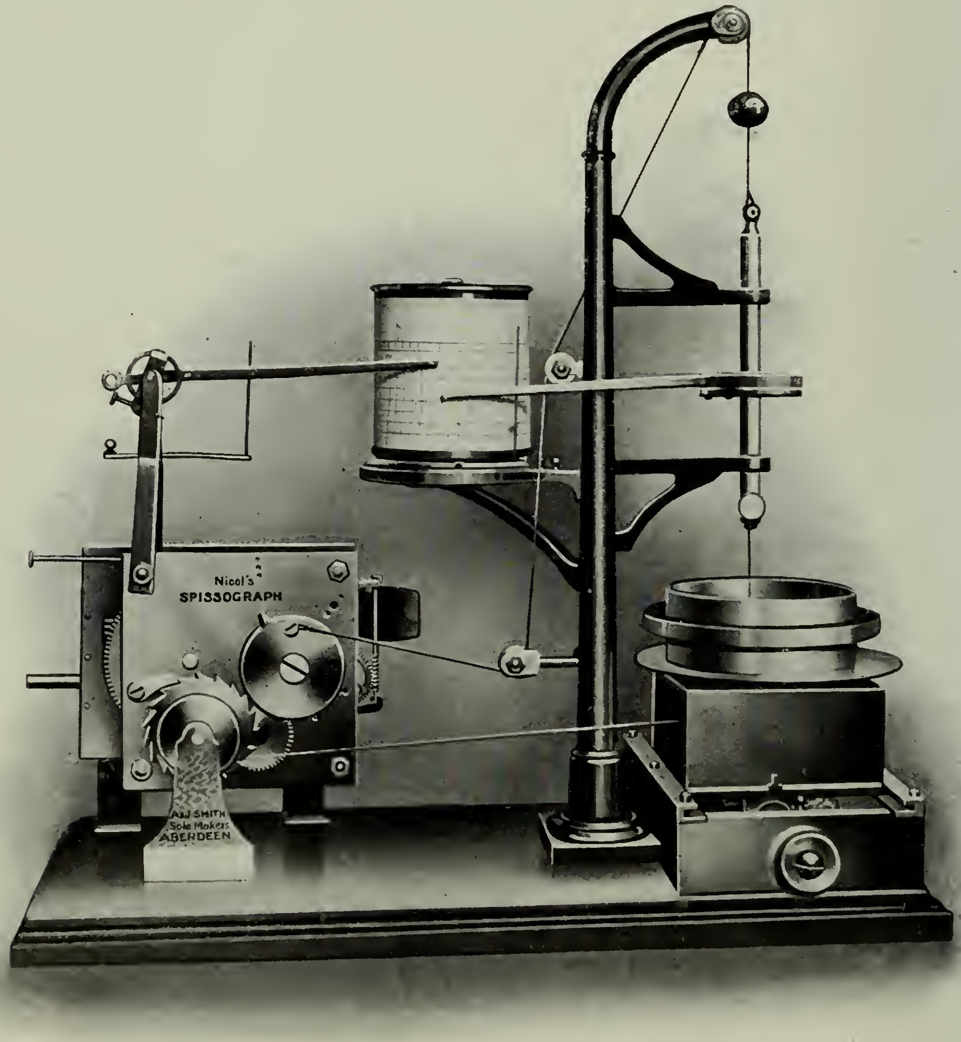
Fire Test of Concrete Block Construction.—The concrete block system of wall construction was recently subjected to a severe fire test at Baltimore, Md., when a four-storey warehouse caught fire. This fire was fought with considerable care, as the firemen expected that the walls, three of which were exposed and self-sustaining, would crumble and fall as in the case of brick walls. In the early stages of the fire the roof collapsed, and the interior of the building became a furnace of burning oil and oil-soaked wood. However, the walls did not fall, and when they were inspected afterwards not a cracked or injured block could be found, although the mortar was burned to some depth in the joints between the blocks and had to be replaced.—*Times Engineering Supplement.*

Concrete Supports for Water-Pipes.—The Water Committee of the Birmingham Corporation report that the works undertaken last year for the strengthening of certain sections of the Severn syphon by filling in concrete under the pipes, have proved entirely successful ; no bursts having taken place on any of the sections. The total number of bursts during the past summer showed a large reduction. The directors of the Great Western Railway Company have called attention to two short lengths of pipes at present unprotected by concrete on the steep ground to the east of the Severn Valley Railway, pointing out that any serious burst on this section of the aqueduct might be attended with grave consequences. In view of the experience of the effective protection afforded by the concreting carried out last year, the Water Committee have resolved to undertake the concreting of these lengths by way of precaution.—*Journal of Gas Lighting.*

Apparatus for Testing Setting Time of Cement.—Messrs. A. & J. Smith, Maxwell House, Aberdeen, have issued a circular advertising the Nicol's Spissograph, a new apparatus for automatically testing and recording on a chart the time of the setting points of cement.

Up to the present all such testing appliances have required continuous and close personal supervision, and as the setting time often extended over several hours, the reliability of these tests has not been altogether satisfactory.

The apparatus here illustrated entirely does away with the need of this personal supervision, for when once started it requires no attention until the test is complete, except to be wound up every three hours in cases where the setting takes more than that time. The winding in no way interferes with the test.



The Spissograph was invented by R. Gordin Nicol, M.Inst.C.E., Aberdeen, and consists of a clock-work which raises and lowers the needle and weight every three minutes, during which time the sample rotates spirally, and thus the needle comes into contact with a fresh surface every few minutes. Attached to the apparatus is a thermograph, which records on the same chart the temperature of the air during the test.

The apparatus is in a glass-fronted thermostat which contains a gas-regulator so adjusted as to keep the temperature at an even level. The water and the cement should also be kept in this case, so that everything is at the same temperature at the time the test is started.

The circular concludes with instructions as to the method of using the Spissograph.

Reinforced Concrete for Hulls.—A German contemporary gives an interesting description of a small motor-boat constructed of concrete. The length overall is 14 ft. 8 in., by 5 ft. 6 in. beam, and 2 ft. 3 in. draught. A 3-h.p. motor is fitted, giving a speed of six kilom. The concrete, which is $\frac{1}{2}$ in. thick, is mounted on a network, having $1\frac{1}{2}$-in. mesh, supported by fore and aft cross iron rods. This is covered with an inner and outer skin of fine-meshed wire gauze. The process of plastering the whole is carried out after the engine bearers and floor frames have been fitted. The keel, by the way, consists of a 1-in. iron bar. Five coats of paint were given, each coat taking two days to dry, while the concrete took three weeks. The cost of the hull came to £16 10s.—*Motor Boat.*

Concrete in the Garden. — Wherever sand is abundant, labour cheap, and cement not too expensive, much outlay on brick and stone structures may be saved by substituting concrete. We have seen it used for the walls of greenhouse and frames, for boundary walls, and as flooring. In countries where frost is not experienced, concrete when properly made and laid is practically indestructible. A novel use of concrete is in the making of fence posts. The concrete is made by mixing 4 parts of sharp sand with 1 part of cement. The cost of each post is less than 2s. Cement is used for making water tanks, stout wire netting forming the frame, on both sides of which the cement is moulded. These tanks are very strong, cheap, and they last many years. The Dutch nurserymen use cement for the walls of their greenhouses and plant frames. Where rats are troublesome cement makes an excellent flooring for sheds, fruit stores, etc. It is better than asphalt for paths that are required to be water-tight. A bag of cement should be kept for use in every garden establish ment, as it can be applied in so many ways.—*The Field.*

Concrete Diving Bell. — The construction of a quay wall near Marseilles led recently to the design of a particularly ingenious form of diving bell. The main wall, with a total height of 50 ft. and a maximum thickness of 16 ft. 6 in., was built of solid concrete in sections 33 ft. long, separated by gaps 15 ft. wide, and to join these up it was necessary to work in compressed air. The difficulty was to find a practicable and economical way of applying that method. The solution proposed by the engineer consisted in boarding up the two open sides of all the rectangles to be filled, from sea bottom up to about 17 ft. below water level, then to close the top of each chamber so formed by a hollow slab of Hennebique reinforced concrete, with a central chimney of the same material, to which access was given by an air-lock attached to the top. This contrivance, something like a bedroom candlestick with a square base and a hole right through the bottom, was built on shore, and having been lowered in position the slab closed in the top of the submarine chamber, while the chimney stuck out above the level of the sea. It was then quite easy for workmen and materials to be passed down the shaft for completion of the wall. The novel diving bells were very light and inexpensive, and after their intended purpose had been fulfilled they were embedded in the concrete of which the upper part of the quay wall was formed.—*Glasgow Herald.*

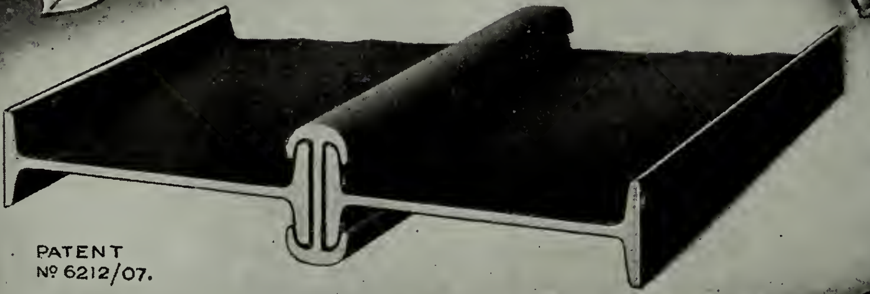
Concrete Caissons for the Municipal Building, New York. — A pneumatic caisson sinking record has just been made in the foundations for the Municipal Building, New York. A caisson for one of the column piers was sunk through sand to rock at a depth of 112 ft. 1 in. below water level without accident or casualty of any kind. The caisson is of concrete with a reinforced cutting edge, and supports a concrete shaft 10 ft. 9 in. in dia., cast before sinking. The construction of the caisson was commenced April 15th, and the bottom was passed May 16th. While under the maximum pressure of 47 lbs. the work was executed by 20 five-man shifts working about forty minutes each, with a very long time for decompression and an interval

USED AT
H.M. DOCKYARD
ROSYTH
WALMER
ACCRA WATER-WORKS
HEATON PARK RESERVOIR
SOUTHERN NIGERIA RLY.
DEPTFORD CREEK
BRIDGE &c
&C. &C.

UNIVERSAL JOIST STEEL SHEET PILING

USED BY
THE ADMIRALTY
CROWN AGENTS
FOR THE COLONIES
QUEENSLAND AND
WESTERN AUSTRALIAN
GOVERNMENTS
& LEADING
CONTRACTORS
&C. &C.

1. Each pile consists of an Interlocking member and Joist, which are driven together.
2. The Interlocking member is always driven over the flange of last Joist driven, so that it does not fill with soil.
3. Drives freely and pulls freely.
4. Practically watertight without caulking.
5. Can be driven at one-fourth the cost of timber.
6. Can be used repeatedly.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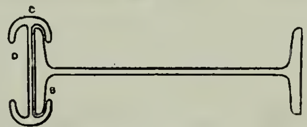

Size of Joist.	Weight per square foot when interlocked.	Weight of Joist per foot run.	Weight of Clutch per foot run.	A	B	C	D
15 in. × 6 in.	43 lbs.	39·5 lbs.	15·5 lbs.	·4 in.	·59 in.	·5 in.	·25 in.
12 in. × 6 in.	52·6 lbs.	39 lbs.	15·6 lbs.	·44 in.	·664 in.	·6 in.	·25 in.
10 in. × 5 in.	58·4 lbs.	35 lbs.	15·5 lbs.	·42 in.	·625 in.	·6 in.	·25 in.
8 in. × 5 in.	62·09 lbs.	28 lbs.	15·5 lbs.	·33 in.	·575 in.	·5 in.	·25 in.
6 in. × 5 in.	76·2 lbs.	26 lbs.	15·5 lbs.	·41 in.	·52 in.	·5 in.	·25 in.
5 in. × 5 in.	58·18 lbs.	24 lbs.	15·5 lbs.	·37 in.	·551 in.	·5 in.	·25 in.

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of four hours between the two shifts each man worked daily. The men were under very strict physical and medical supervision, improved sanitary and hospital appliances were on hand, and a competent physician was in constant attendance, and not even a single case of illness occurred. This is believed to be the deepest pneumatic caisson ever sunk, and is expected to be the maximum for this building, which will have 106 caissons, over half of which have been sunk.—*The Engineer.*

The city of Toulouse has recently been provided with a new and very remarkable bridge, called the Bridge of the Amidonniers (starchmakers), which spans the Garonne River a little below the St. Pierre Bridge. The new bridge is the first large work of its peculiar type, and has been constructed from plans by M. Séjourné, after the model devised by him for the bridge at Luxemburg. This type of bridge is characterised by the association of two parallel masonry arches connected by a floor of reinforced concrete. The Toulouse bridge, the entire length of which is 730 ft., contains five such pairs of elliptical arches. The largest pair, in the middle of the bridge, has a span of 150 ft. Each arch of the pair is about 16 ft. wide, and the two arches are separated by an interval of 33 ft. By allowing the transverse girders of the concrete floor to project beyond the arches, the builder has obtained room for two overhanging walks and parapets. Thus, although the combined width of the two masonry arches is only about 20 ft., the total available width of the bridge is about 70 ft. This method of construction results in great lightness of appearance and an economy of material and money.—*Building News.*

Concrete Casings for Wooden Piles have been used with great success in wharf and bulkhead construction on the San Francisco water front by the Board of State Harbour Commissioners. These casings are reinforced concrete hollow cylinders cast in any required size on shore, and allowed to set there until needed. In the application of these casings the wooden pile, of whatever size and length required is first driven to the desired depth, and the casing then slipped over the pile, and in turn is driven as far as desired. Then the interior of the casing is pumped out, the mud or sand removed to the required depth, and the annular space around the wooden pile filled with concrete. For the bottom of the casing special shoes are provided which fit reasonably close around the wooden pile, thus ensuring a uniform thickness of concrete filling, and preventing any large amount of mud or sand from entering the casing during the driving. In the San Francisco work casings 24 in. in diameter and from 22 to 56 ft. long have been used. For longer lengths a special splice is provided.—*Contract Record.*

Contracts for Portland Cement for Brazil.—The Associated Portland Cement Manufacturers, 1900 (Limited), have recently entered into contracts to supply the whole of the Portland cement required for three important works now in progress in Brazil, *i.e.*, the National Arsenal at Rio de Janeiro, and the Port works at Pernambuco and at Bahia. These contracts are estimated to require approximately 100,000 tons of cement.

W. B. Brown & Co., Globe Works, Bankhall, Liverpool, inform us that the judges of the Buenos Aires Centenary Exhibition have awarded them a silver medal and diploma for excellence in the manufacture of steel wire ropes suitable for mining works, elevators, ships and steamers' use, which award is the highest obtainable in the class devoted to these specialities.

CONTRACTS.

Edmond Coignet, Ltd., inform us that their system of reinforced concrete has been adopted for the following works :—

Road bridge at King's Cross Station for the Metropolitan Railway Company, calculated for heavy traffic and two tramway lines. The width of the bridge will be 60 ft., and the two spans will be respectively 53 ft. and 38 ft. One beam in particular, supporting the edge of one of the footpaths, will have a span of no less than 63 ft. This will probably be the first important bridge in reinforced concrete constructed in London. The contractors for the work are Messrs. Henry Lovatt, Ltd., of London and Wolverhampton.

Floors for Royal Infirmary at Bristol. All the floors of this building (approximately 7,000 sq. yds.) are to be executed in the Coignet system of reinforced concrete. The architect is Mr. H. Percy Adams, F.R.I.B.A., of London.

New Law Courts at Kingston, Jamaica. Architects, Messrs. Nicholson & Corlette, of London ; contractors, Messrs. Mais & Sant, of Kingston, Jamaica.

Floors and roof for New Drill Hall at York. This work is at present being carried out under the supervision of Mr. Walter H. Brierley, architect, of York, the contractor for the work being Mr. William Birch, of York.

Floors for Victoria Works, Bailiff Bridge : Contractors, Messrs. Atkinson & Son, of Leeds.

Floors for the Imperial Paper Mills, Gravesend : Contractors, Messrs. W. F. Blay, Ltd., Dartford.

Winter Garden at Norman Court : Architect, Mr. S. Tugwell, of Bournemouth ; contractors, Messrs. Wakeham Bros., of Plymouth.

Floors for Carpet Warehouse, Bailiff Bridge : Architects, Messrs. Walsh & Nicholas, of Halifax ; contractors, Messrs. Henry Atkinson & Sons, of Leeds.

Piles for Southampton Town Quay : Engineer, Mr. Cooper-Poole, Southampton ; contractors, Messrs. J. Moran & Son., Ltd., of London.

Warehouse at Dyche Street, Manchester : Architect, Mr. Isaac Taylor, of Manchester ; contractor, Mr. Robert Carlyle, of Manchester.

Tank for the Powell Duffryn Steam Coal Co., at Bargoed : Contractors, Messrs. Watt Bros., of Cardiff.

Jetty in the Camber Portland for the Admiralty : Contractors, Messrs. Wakeham Bros., of Plymouth.

EDITORIAL MEMOS.

CONTRIBUTIONS.—Original contributions and illustrations are specially invited from engineers, architects, surveyors, chemists, and others engaged in practical or research work. MSS. should be written on one side of the paper only, giving full name and address of the author.

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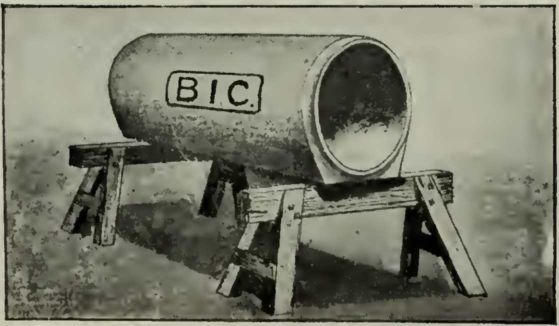

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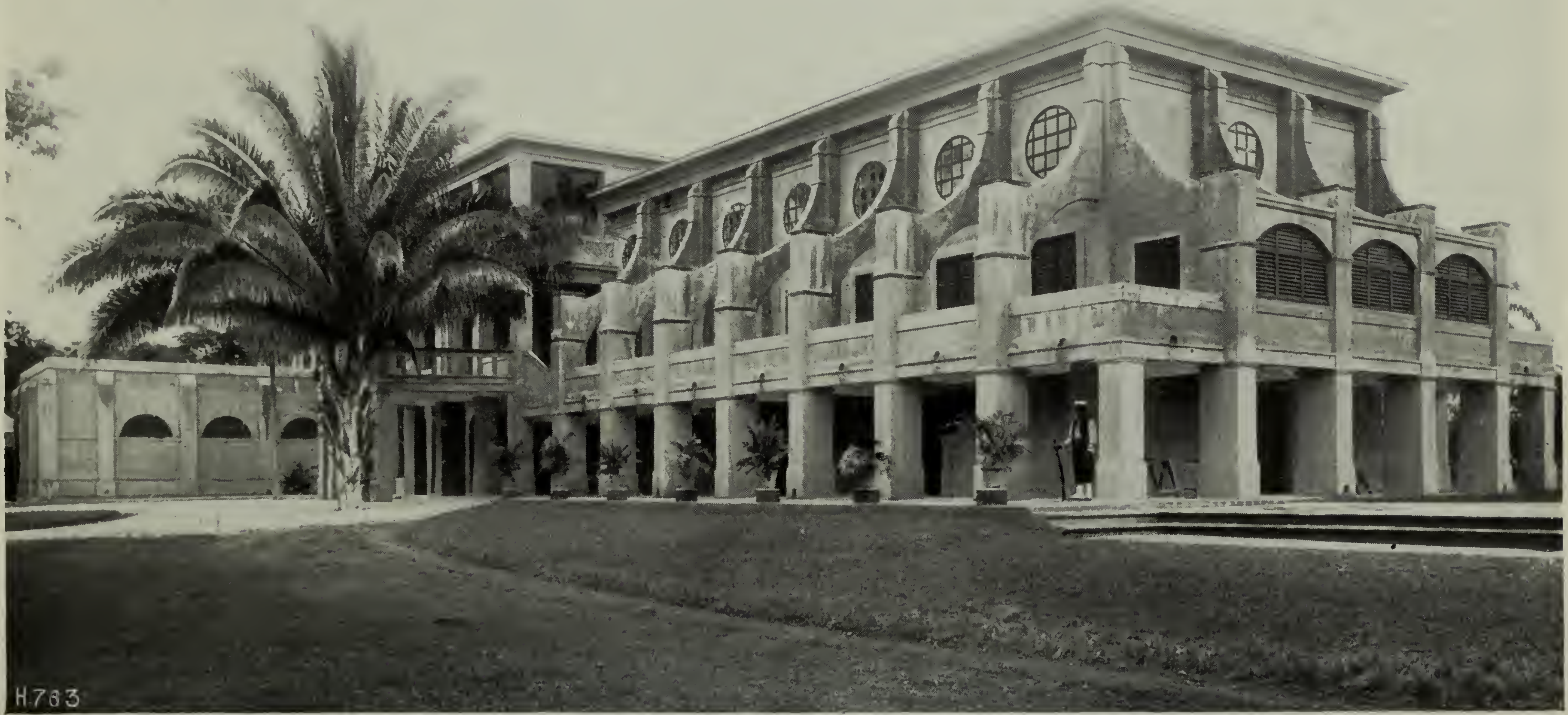
Concrete Beams

Hollow Floors

SPECIALITY :—INVENTORS' DESIGNS CARRIED OUT TO ORDER.



The King's House, Kingston, Jamaica.
Reinforced Concrete Public Buildings at Kingston, Jamaica.

Frontispiece
(Opp. Contents)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume VI. No. 2. LONDON, FEBRUARY, 1911.

EDITORIAL NOTES.

THE LOCAL GOVERNMENT BOARD AND THE WATER BOARD.

WE have received several letters from abroad regarding the recent correspondence between the Local Government Board and the Metropolitan Water Board as to the latter's proposal to lay a reinforced concrete main of 48 in. diameter, and thereby save some £4,000 in capital expenditure as compared with the cost of a cast-iron main. The Local Government Board allow a loan period of 30 years on cast-iron mains, but for reinforced concrete the loan period was to be limited to 15 years. Further, the Water Board were required to undertake experiments and tests prior to constructing the reinforced concrete mains, and this research work would have meant a considerable expenditure of time and money.

Our foreign correspondents point to the policy of the Local Government Board as something very amusing, particularly to their describing the use of reinforced concrete mains as an "experiment." The many miles of reinforced concrete mains used on the Continent are quoted to us as excellent, long-standing examples of reliable work done, and surprise is expressed at the Local Government Board publicly advertising its ignorance on the subject in so ridiculous a manner. Our correspondents emphasise their strictures by reminding us that quite a number of our Government officials fully know the value and reliability of reinforced concrete mains, and have personally inspected examples abroad, and that it appears quite farcical to them that the "right hand apparently does not know what the left hand has been doing" in matters of this kind, for the Local Government is but one of the many departments of the self-same British Government which builds post offices, jetties, etc., in reinforced concrete.

At first we felt rather inclined to resent the jocular tone of our correspondents. We naturally dislike to have our public authorities contemptuously referred to by foreigners. But on second thoughts we are afraid the remarks are quite in order and in accordance with the fashion set by Mr. Roosevelt when dealing with the British policy in Egypt. That the criticisms are to the point goes without saying. The Local Government Board has long been the laughing stock of the technical professions at home as far as its attitude regarding reinforced concrete is concerned. It will now obtain a kind of international notoriety for ignorance as to reinforced concrete, and a few more letters of the type addressed to the Metropolitan Water Board as to the "experiment" of laying reinforced concrete mains will give it quite a unique position among the Local Government Departments of civilised nations.

The net result of the Board's attitude is, however, no laughing matter. Cast-iron mains costing an additional £4,000 are to be put in by the Water Board, who cannot afford to execute new works on a 15 years' loan period. As the total expenditure proposed was about £18,000, the saving that ought to have been effected was about 22 per cent., whilst the efficiency obtainable for the lower figure was equal—maybe greater—than what is now about to be provided.

We wonder how much longer the Local Government Board is to be allowed to bar technical progress and economy?

It is time Parliament inquired into the matter and demanded a public inquiry into blundering of this description.

SIR HENRY TANNER AND THE NEW GENERAL POST OFFICE.

THE opening of the New Year was marked by the presentation of a thoroughly practical paper in the rooms of the Royal Institute of British Architects. The new General Post Office buildings were under review—more particularly their structural features—and Sir Henry Tanner, the architect of these imposing offices, was the reader.

We have dealt with the buildings in these columns from time to time, and a summary of the paper and subsequent discussion is given under " Recent Views " in this issue, thus we will only comment here on a few of the points brought out during the evening, which, we think, are of special interest, and have an important bearing upon current practice.

REGULATIONS AS TO REINFORCED CONCRETE.

Sir Henry Tanner pointed out that full advantage was taken of the new method of construction in reinforced concrete in both the design and erection of the new General Post Office, this only being rendered possible by reason of the exemption of Government buildings from the operation of the London Building Acts. Some speakers in the subsequent discussion inferred that when the new regulations upon reinforced concrete construction at present being drawn up by the London County Council are issued, restrictions will be imposed which will preclude such a great saving being made as was effected in this building, and argued that if they had been in force in this case they would have prevented its construction in the form which has proved to be so eminently satisfactory. That, however, is a mistake, as the draft which has been brought before the technical societies is not unduly stringent.

Of course, regulations must be made for all and sundry, and it is right and proper that Government buildings should be exempted, for on such works exceptional supervision can be given to ensure the work being of superior quality to the average, and these new regulations will probably be found when they are eventually issued to be very different from former by-laws, because it is surmised they will contain provisions enabling general conditions to be waived in special circumstances, such as in the erection of structures like the new General Post Office. For example, we may cite the question of super loads on floors which were remarked upon as being particularly light in the case in question. The loads were, however, ascertained from the results of experiments, and such proof would, no doubt, be accepted as being thoroughly satisfactory by the London authorities. Architects are accustomed, as a rule, to grossly overestimate the loads that can be imposed on the structures that they design.

Sir Henry Tanner showed in this instance that the greatest load which could be imposed upon the floors was ¾ cwt. ; now most architects would think 1 cwt. a minimum for such a structure, and, indeed, we find blocks of flats and such like structures required to be designed for a super load of 2 cwt., whereas 50 lb. per sq. ft. would be ample.

Another point mentioned was the rendering of the external walls. A mixture of 1 of cement to 2 of sand showed hair cracks on the surface, and Sir Henry Tanner expressed the opinion that it would have been better to increase the proportion of sand, because the tendency to crazing is greater the richer the mixture is in cement. Pure cement shows greatest contraction, whereas a weak mixture shows very little alteration in volume in setting and hardening.

STORAGE AND USE OF CEMENT.

It was also mentioned that the cement was stored in water-tight sheds, but was not spread out. Of course, the fact that it is unnecessary to cool the modern finely ground cement by leaving it for a time in thin layers in a shed is now thoroughly established among experts, and Mr. Bamber and other speakers demonstrated this at the Institution of Civil Engineers only recently, yet one still sees the old specification clauses repeated. By such exposure the cement of to-day is damaged, and cement on the works should be stored not only in water-tight sheds, but in proper air-tight and draught-proof bins. It is not well even to store it in sacks in water-tight sheds, for the moist air will cause the outside portion of the cement to cake after a very short while, which means that the cement will have lost a very great deal of its strength. Really, the cement of to-day is so very unlike what it was only four years ago when the Post Office was being built, that it might almost be called an entirely new article. People do not realise the progress in manufacture, and the result is that the majority of the architectural and engineering professions cannot adjust their ideas to the altered conditions, and are either wasting cement or stressing the materials too low, so that there is equal want of economy. There is no doubt about our English Portland cement of to-day being far superior to that until recently obtainable on the Continent or in the United States. We cannot otherwise explain the compressive resistance that we are able to obtain from the same kind of aggregate and the same proportions as are being tested by American professors of engineering. The labour in making our test blocks is not superior to that employed in America or on the Continent—it is simply the cement that makes the difference.

IMPORTANCE OF SUPERVISION.

A speaker in the discussion called attention to a remark of Sir Henry Tanner's, that great care is required to properly and accurately place the reinforcements, and that supervision has to be ample, otherwise workmen are inclined to be careless, and to save themselves trouble to the detriment of the work. The conclusions drawn by this speaker were that the risks on this score were so considerable that reinforced concrete as a method of practical construction was at a great disadvantage. Sir Henry Tanner's remark is a very pertinent one, and it proves the very great importance of thorough supervision by clerks of works over even those contractors who have had much experience with reinforced concrete, for they employ all sorts of men who are unaccustomed to the work, although they may keep a certain number of old hands. The experienced contractors, of course, are in a better position than others, because their foremen are more reliable and better able to lay their fingers on the weak spots, knowing what errors may very likely be made from their having experienced such mistakes before.

Mr. Max Clarke, in the course of the discussion, remarked that "there was a considerable amount of luck at the present time in reinforced concrete work; if one did not have supervision, one had luck, and he congratulated Sir Henry Tanner on having had both supervision and luck." Mr. Clarke is right. Absence of supervision means trusting to luck, and although good fortune has largely assisted reinforced concrete in the past as far as England is concerned, it is supervision that is all essential to prevent the possibility of failure. All concerned in reinforced concrete work should welcome supervision, be it that of the architect and his staff or that of the local public authority.

However, all forms of construction require careful supervision, and if this is ample reinforced concrete can be depended upon. Indeed, the number of failures is very small, and appears to form a much lesser proportion to the total amount of work executed than in any other branch of the building trade. That, however, might not be so if the work gets into the hands of inexperienced and unscrupulous people, but with the increasing knowledge of the subject which is now obtainable these errors are not so likely to arise, and the necessity for great care will be better realised by all those connected with the design or the supervision of reinforced concrete work.

CO-OPERATION OF ARCHITECTS AND ENGINEERS.

One part of Sir Henry Tanner's remarks, which perhaps was most suggestive, was with reference to the mode of procedure to be employed in order to ensure efficiency in regard to reinforced concrete design. He was of opinion as the result of experience of various methods of procedure, that that pursued with the new General Post Office was by far the best. The truth of his remark that it was of the greatest possible advantage that the architect and engineer should be able to work together will be readily admitted. This he thought could not be done when designs and tenders were called for at the same time, and he pointed out that where there is competition in price the design is cut down to the minimum, so that the chances of failure are increased. He also added that time is lost in the examination and comparison of the designs submitted, this meaning loss of money on interest where sites are vacant. He pointed out that steelwork is not ordinarily dealt with by architects in the same way—namely, by requiring tenders to be both in design and price at the same time from the same firms, and that variations are difficult to value where there is no schedule, so that he thought in time reinforced concrete must be dealt with like the rest of the construction and included in the ordinary bills of quantities for which general contractors would be able to tender. There is much truth in this view.

In 1905, when the building referred to was begun, although reinforced concrete was then about 45 years old, it had only been employed to any extent abroad in its modern development for about 15 years, and there had been only about seven years' experience with buildings of any scale in England. Consequently Sir Henry Tanner showed considerable courage in employing it for a Government building, particularly one of such magnitude. The Local Government Board still puts obstacles in the way of reinforced concrete, though the other Government departments have followed the lead of the Office of Works. At the time this work was undertaken we can quite well understand his engaging the expert designer with the largest experience. There was, of course, much heart-burning among competitors, and subsequently other jobs were thrown open to competition, with the result that firms have been called upon to furnish many drawings and go through a tremendous amount of duplication of work which has been of no advantage to the public nor to themselves in most cases. In the early stages of the development of a new form of construction the position must be somewhat awkward, and there must be duplication by such competition which, however, is the refining fire that eliminates the inefficient and the inferior.

There is as much call for competition in engineering design as in architectural, but to-day the position is such that we may call for such competition to be in design alone without asking for a price. The assessor in a competition would, of course, consider the suitability of the design both as regards the cost and the efficiency for the work in hand, whereas otherwise efficiency is often sacrificed to price. Thus a good design would stand a chance of being accepted, whereas it might by the accidents of tendering, or by reason of one or two contractors keeping up their prices or not being anxious for the job, be excluded in the ordinary way. Design is becoming more standardised, and much more knowledge is possessed by those who undertake this work to-day, so that in the majority of cases competition in this particular is not requisite, and thus the waste of labour by duplication is unnecessary, and can only be of disadvantage to everyone. The specialist designers who have been forced to submit tenders with their plans are quite ready, of course, to design works as consulting engineers.

It is pretty certain, however, that specialist designers will always be necessary for reinforced concrete, even more than for steelwork, which, although it has been used for so many years now, is not in any extensive case designed by architects themselves. Reinforced concrete design is an intricate matter requiring special knowledge, and though, no doubt, the architectural profession will become more familiar with its general aspect and may design simple beams, specialists will be needed in most cases. For larger engineering works we may anticipate that special firms will still continue to tender on both design and price, the same as is done for steel bridges for instance. There are certain large structures which are open to particular specialisation, and a few firms could fit themselves to undertake such work with greater efficiency and economy than could the ordinary contractor who worked on the plans of the ordinary specialist consulting structural engineer. In due time the matter will settle itself, but the opinions of an eminent architect who has had exceptional advantages of trying various methods, and who has had much experience of large and important undertakings as well as of the new system of construction, must carry great weight.

MR. ISAAC CHARLES JOHNSON'S HUNDREDTH BIRTHDAY.

On Saturday, January 28th, 1911, Mr. Isaac Charles Johnson completed his hundredth year. This event is sufficiently rare for it to be noteworthy, and, as Mr. Johnson's life has been spent in the cement trade, it seems only right to allude to the occurrence in this journal.

The history of Portland cement since its invention by Mr. Aspdin about the year 1824 has yet to be written in full detail. Messrs. Robins and Messrs. John Bazley-White & Son were the first to take in hand the manufacture of the new material. At that time Mr. Johnson was in the employ of the latter firm.

Hitherto Roman cement had held the field. This cement, as is well known, is what is called a "natural" cement; while Portland cement is called "artificial"—*i.e.*, it is based on the idea which occurred to its inventor that the ingredients of which Roman cement was composed might be artificially mixed in such proportions as to ensure greater strength and hydraulicity. The mere suggestion soon led to experiment and research in this direction, with the result that by degrees Portland cement, which took its name from its similarity in colour to Portland stone, was improved in quality, and the methods of its manufacture emerged from their primitive crudity, so that it has come to pass that cement of the highest quality is to-day widely and scientifically manufactured. In the middle of the last century Mr. Johnson took his share in working out these improvements and founded the firm which bears his name. In several newspapers it has been said that he was the inventor, but we are glad to see that he has very properly disclaimed this mistaken statement.

Many of the cement manufacturers of England have joined in presenting to Mr. Johnson an address, in which expression is given to their appreciation of his career and their respect for him personally. The text of it is sub-joined. They have also presented him with a testimonial in the form of a silver tea and coffee service of the eighteenth century. On Mr. Johnson's birthday a small committee of the manufacturers visited him and made a presentation of the address and the gift.

Mr. Johnson's life has been marked by qualities of industry and high integrity which have enabled his natural abilities to reap their due reward, and our readers will join with those who have already addressed him in wishing that the remainder of his days may be spent in rest and peace.

The following are the terms of the address:

To ***Isaac Charles Johnson, Esq., J.P.***

We, the undersigned Firms and Companies, desire to express to you our warm congratulations on the completion of your hundredth year on this 28th day of January, 1911.

From an early age you have been associated with the industry in which we are all interested. Amongst us are the successors of those with whom you were closely linked at the very outset of the manufacture of Portland Cement, in the improvement of which manufacture you have notably shared at the various stages of its history. Many have been acquainted with you personally since the middle of the last century, and many more in its later years. All of us have known you as a manufacturer of sagacity and enterprise, and the firm with which your name is connected doubtless owes its acknowledged standing in no small degree to the qualities which you brought to bear on the conduct of its affairs so long as you were actively engaged in business. But not only on the grounds of success in business do we desire to express our appreciation of your career. The commercial qualities have depended largely on personal integrity, intelligence and perseverance, and these as well as your exceptional health and strength are causes for congratulation. It is for these reasons that the Industry of which you are a member has desired to mark an event that happens to very few men, and we ask your acceptance of the gift which accompanies this address in the hope that it may give you pleasure to possess a small mark of our esteem, and that those to whom you may hand it down will by it be reminded that the affection in which they hold you found its counterpart in the appreciation of many with whom in a long life you have had relations.

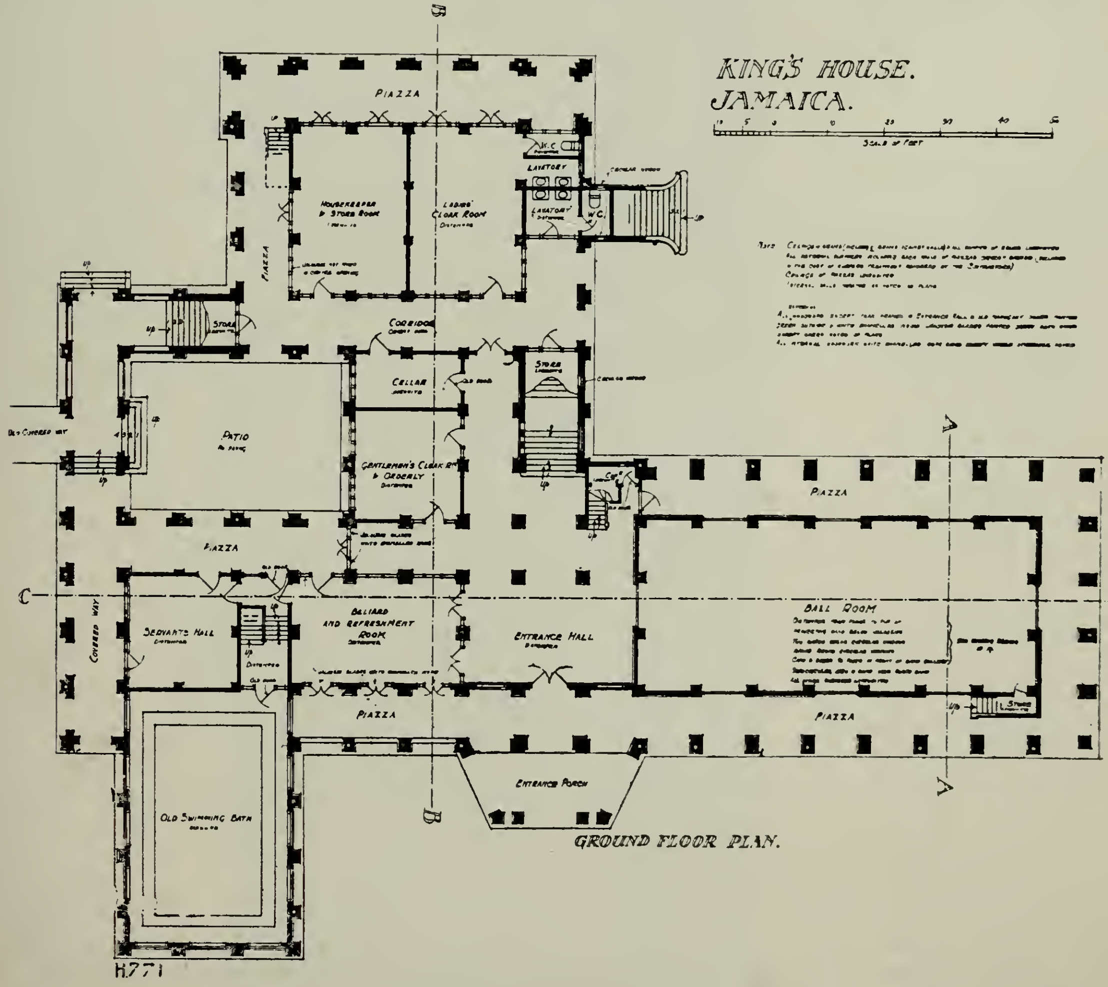
We trust that the evening of your life may be to you a time of peace and happiness.

NEW PUBLIC BUILDINGS AT KINGSTON, JAMAICA.

We have published several articles in our journal on the suitability of reinforced concrete for structures in earthquake districts, and are now giving details of the large public buildings being erected in Jamaica of this material, which ought to be a convincing proof of the advantages of this method of construction for such countries.—ED.

Most of the important buildings in Kingston were destroyed by the violent earthquake which occurred in January, 1907. As usual, in such catastrophes, the position was aggravated by the fact that a fire broke out in various parts of the town.

In order to prevent a recurrence of this calamity the Jamaican Government, when contemplating the reconstruction of their public buildings which had been

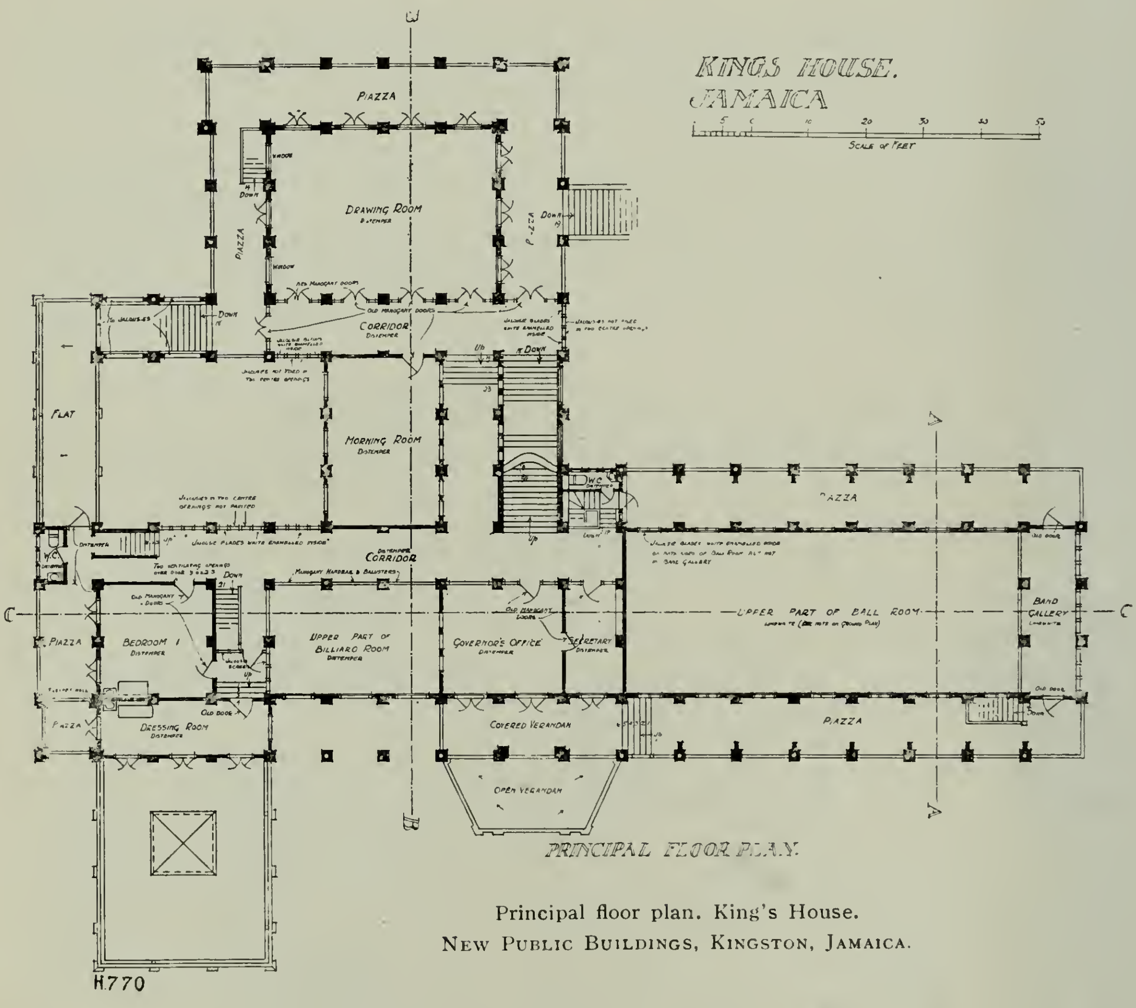


Ground floor plan of King's House.
New Public Buildings at Kingston, Jamaica.

destroyed, thought it advisable, after very careful consideration, to adopt reinforced concrete as being more suitable to resist earthquake shocks and fire than the ordinary materials generally in use for building constructions.

Reinforced concrete seems to have become the ideal system of construction for such districts. This is the outcome of the experience with this material in regions subject to earthquake shocks. Both at Messina, Jamaica, and San Francisco there were a few structures of reinforced concrete, perhaps more in the latter place, and in all cases this method of construction showed up to great advantage, the structures not being damaged in any particular.

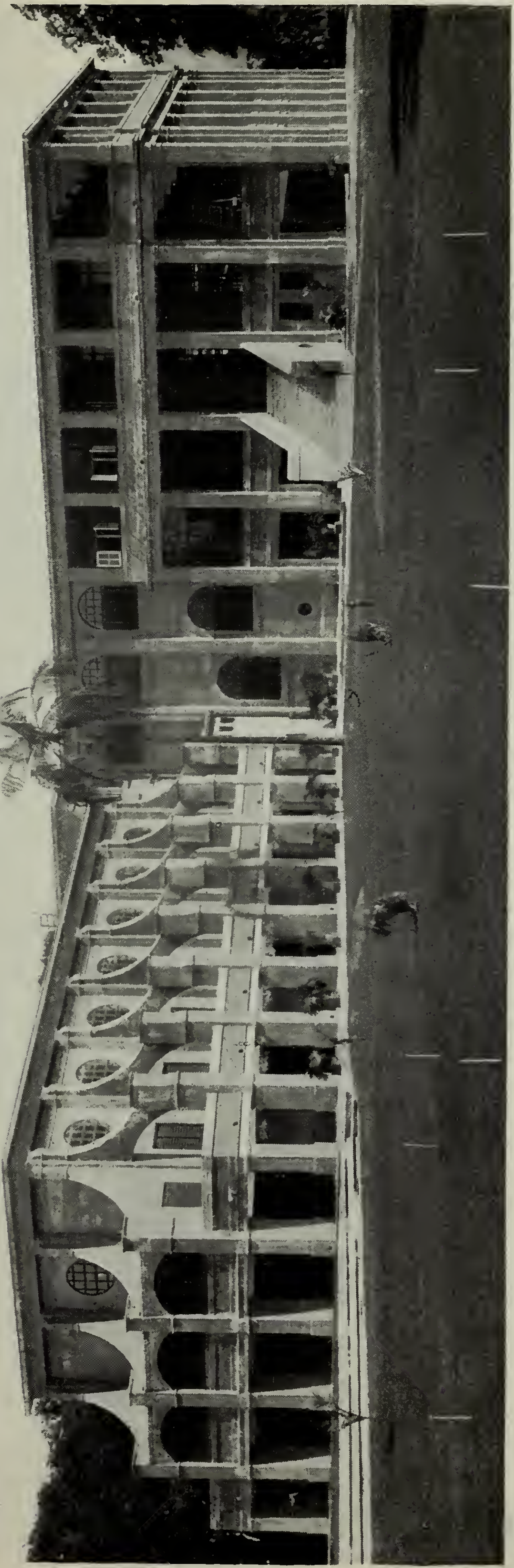
Reinforced concrete structures would appear exactly to meet the case, because they are cage-like in their framing, and the whole of the walls and floors are tied to the frame work, forming a perfectly rigid and monolithic structure, no part of which works away or is distorted from the other. Many reinforced concrete buildings which were erected with no consideration of ever being tried by earthquake, when called upon to meet the shock, passed through the test most satisfactorily. The fireproof nature of this method of construction is, of course, another reason why it is so suitable in such districts.



Principal floor plan. King's House.
NEW PUBLIC BUILDINGS, KINGSTON, JAMAICA.

The architects appointed by the Government, Messrs. Nicholson & Corlette, of London, have designed the various buildings here described. In preparing their plans they had to consider the best means of providing for adequate foundations capable of resisting severe earthquake shocks, and for this reason they found it advisable, after investigating the matter, to have a general raft in reinforced concrete composed of strong slabs and beams uniting the various footings of the walls and pillars in such a manner that the entire work may be considered as monolithic.

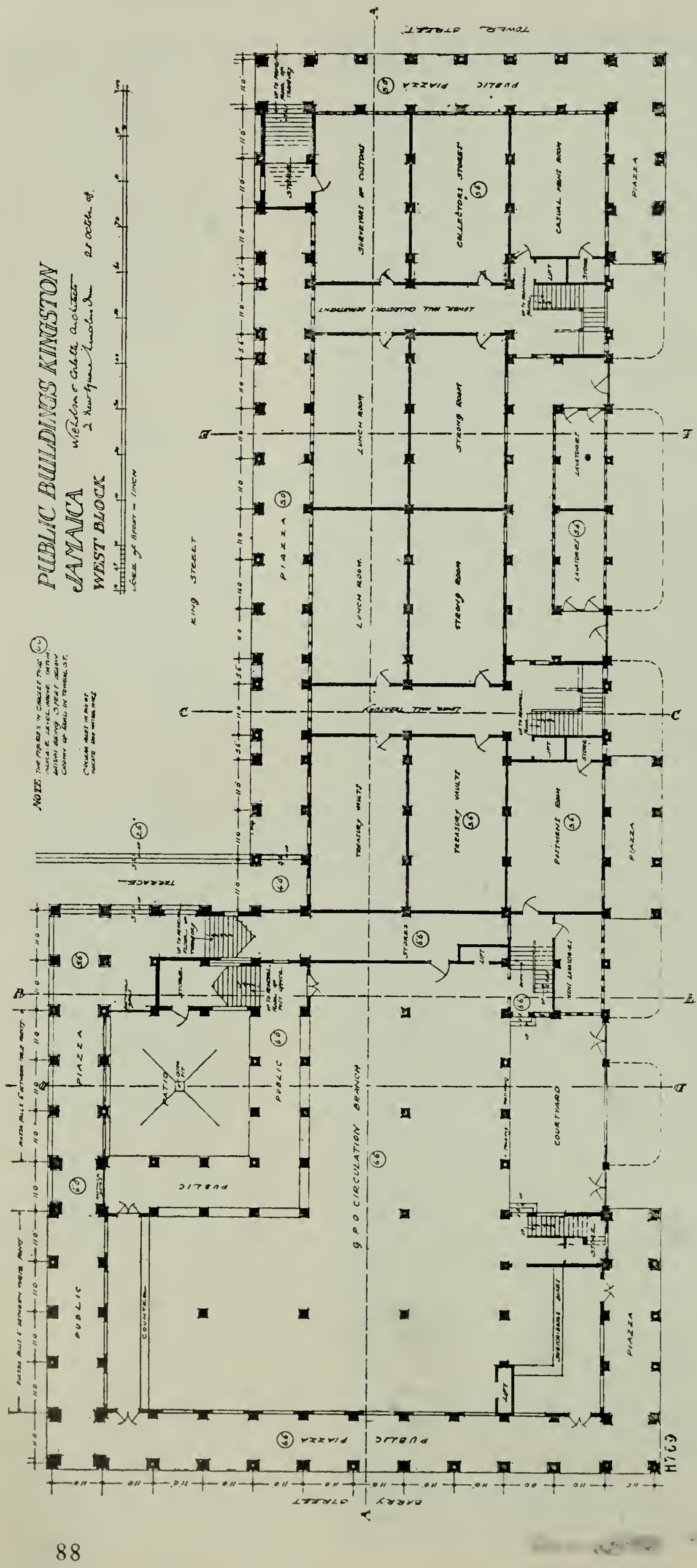
The same principle was adopted both for the General Post Office and Treasury, and for the King's House, the latter being the official residence of the Governor of Jamaica.



New Public Buildings, Kingston, Jamaica.

The King's House.

The photos which we herewith reproduce of these various buildings clearly show the style of architecture adopted as best suited for the requirements of reinforced concrete. From these illustrations the architectural possibilities of the material will clearly be seen, the buildings in question presenting a very fine appearance, and there can be no doubt that not only from the point of view of utility, but also for



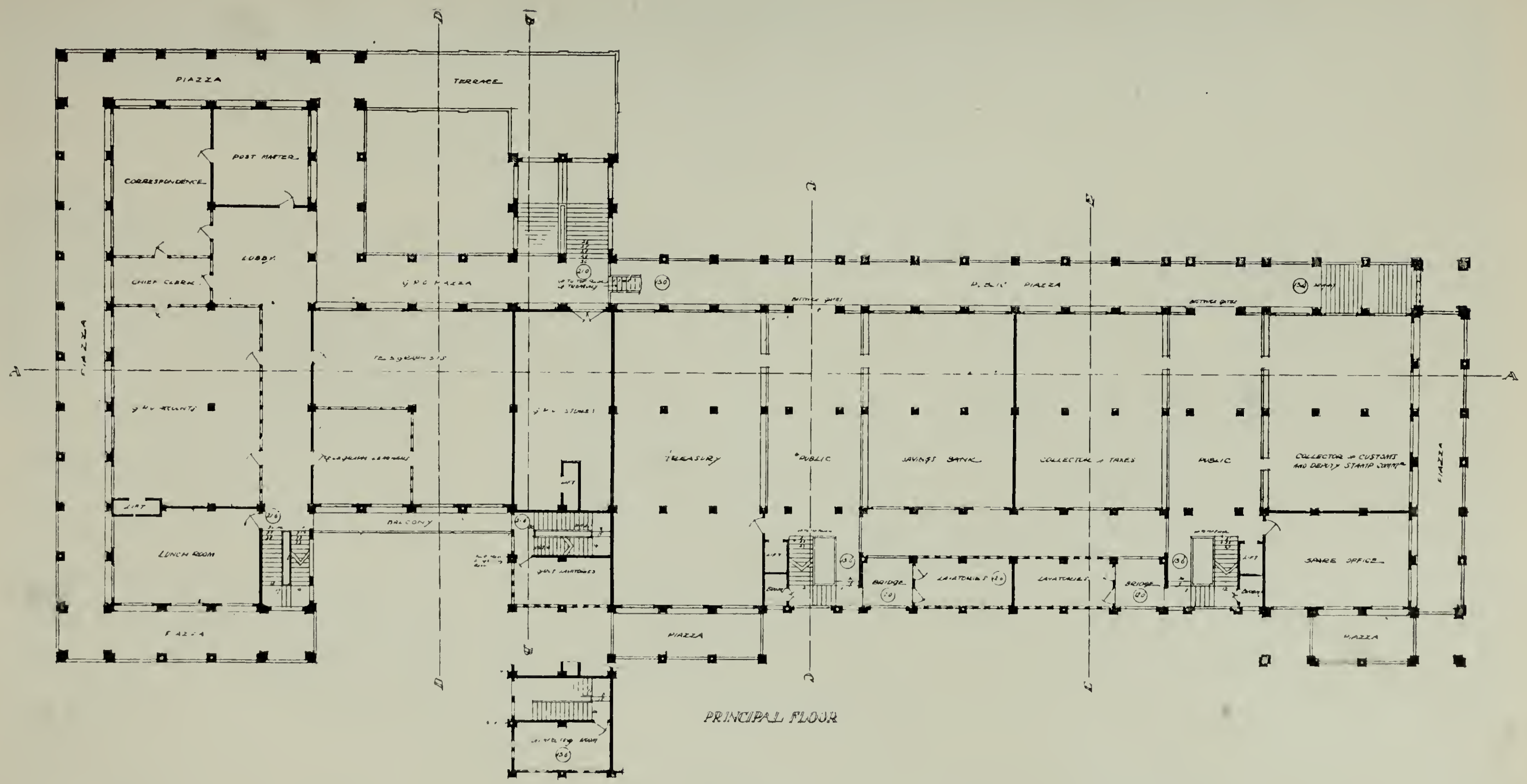
Ground floor plan, Post Office and Treasury Buildings.
New Public Buildings, Kingston, Jamaica.

effective design, it is admirably suited for buildings in tropical climates.

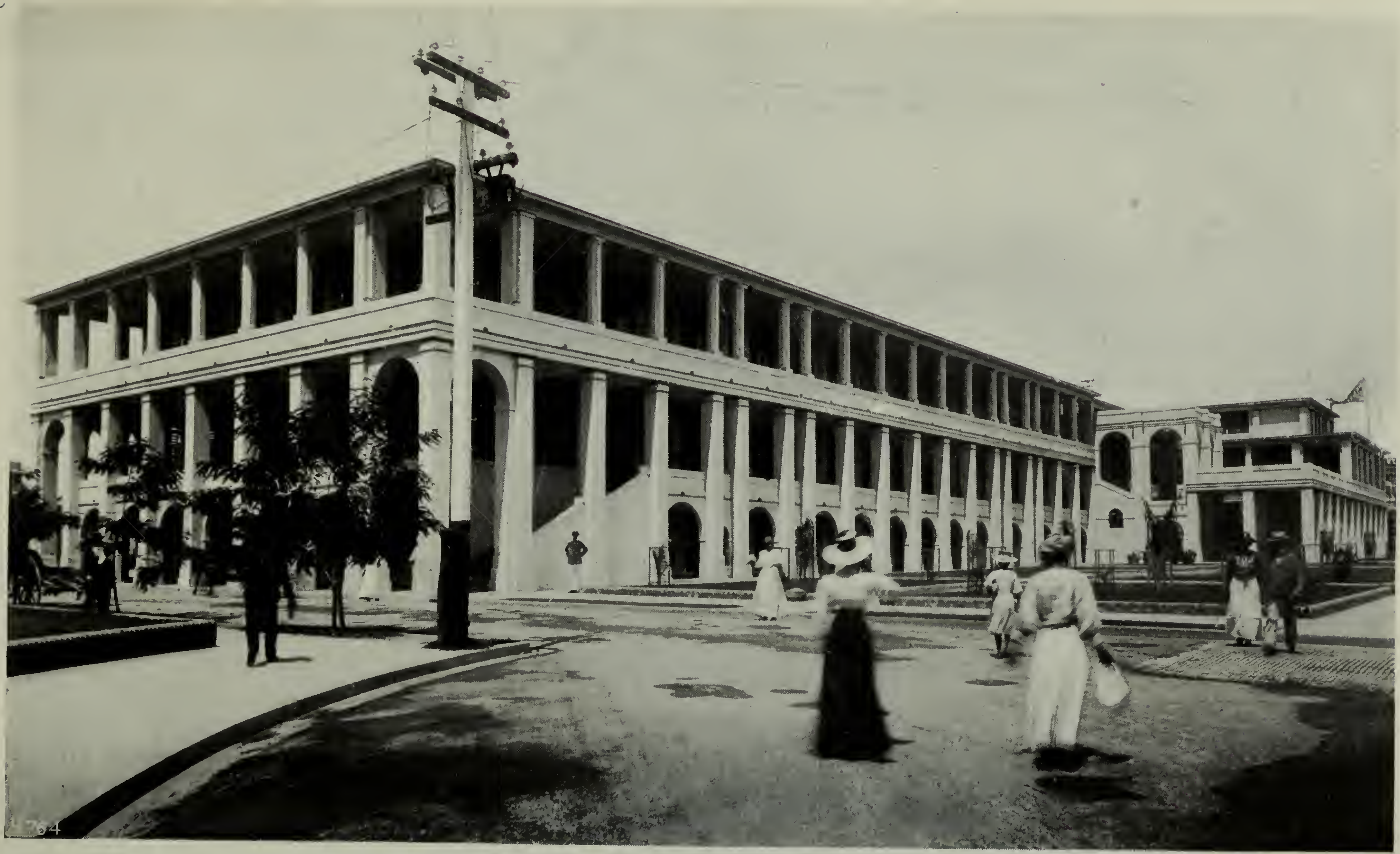
Spacious verandahs and colonnades have been provided as is usual in hot climates. The various roofs are flat, composed of reinforced concrete, and covered with several inches of gravel in order to protect the work against the heat of the sun, flat roofs being considered to offer the least resistance to the force of hurricanes.

The general dimensions of the Post Office building are 121 ft. by 132 ft., and the general dimensions occupied by the Treasury are 187 ft. by 88 ft. These two departments are practically one building. They are composed of a ground floor, principal floor, top floor and roof, the superloads on the floors being 150 lb. per sq. ft., and 84 lb. per sq. ft. on the roofs.

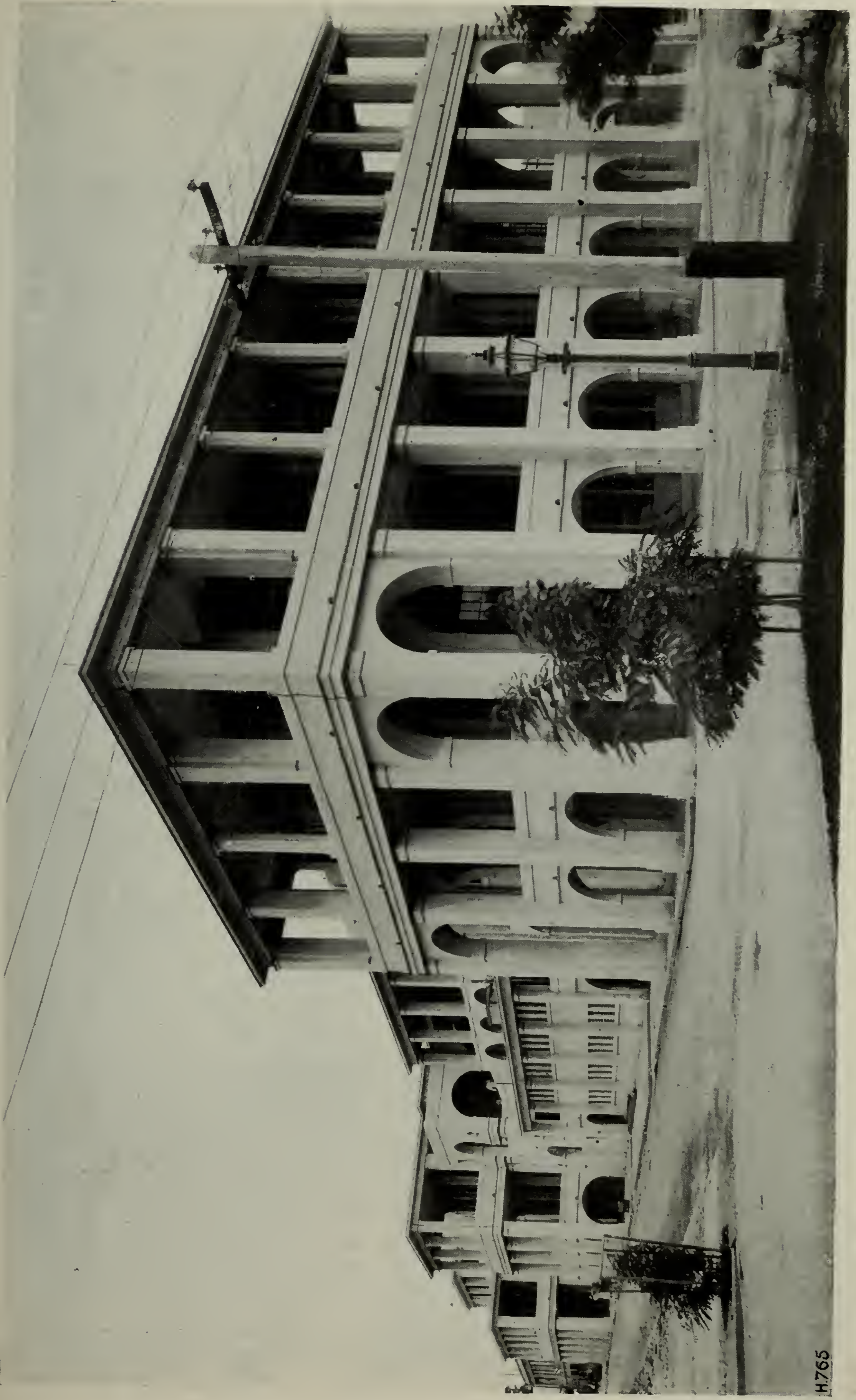
The scantlings of the various pillars are on the ground floor



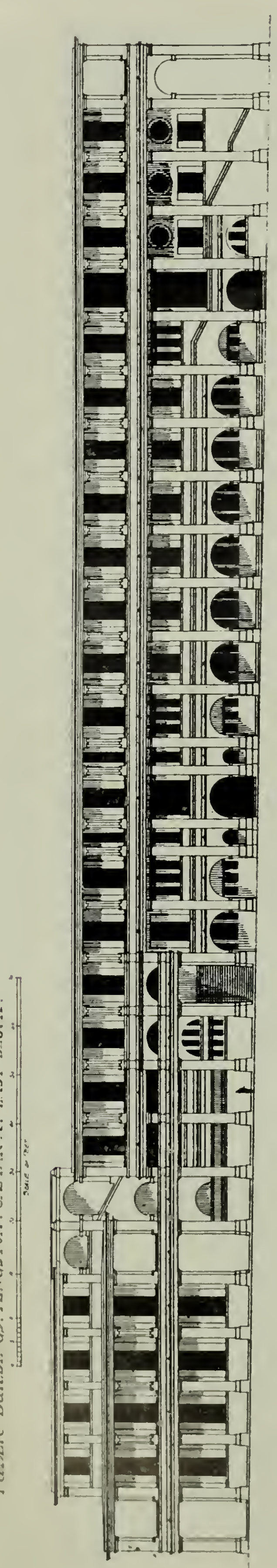
Pr'ncipal floor plan, Post Office and Treasury Buildings.
New Public Buildings, Kingston, Jamaica.

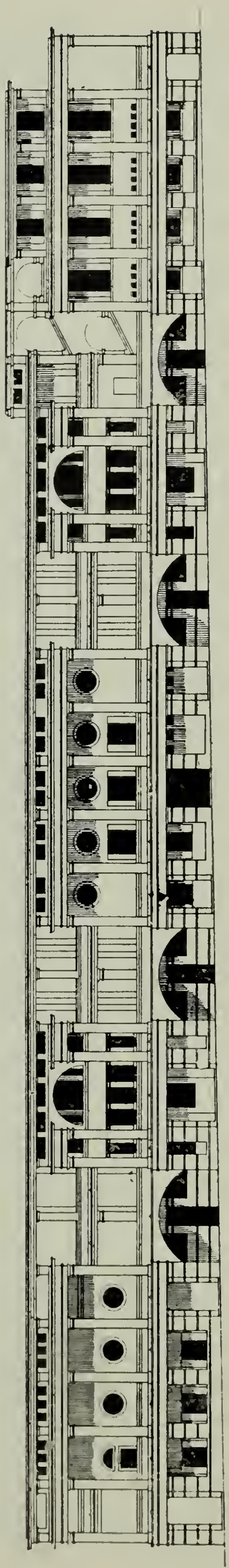


Post Office and Treasury Buildings.
New Public Buildings, Kingston, Jamaica.



Post Office and Treasury Buildings.
NEW PUBLIC BUILDINGS, KINGSTON, JAMAICA.


PUBLIC BUILDINGS, KINGSTON, JAMAICA. EAST ELEV.
ELEVATION TO KING STREET.



EAST ELEVATION.
Law Courts.
New Public Buildings, Kingston, Jamaica.

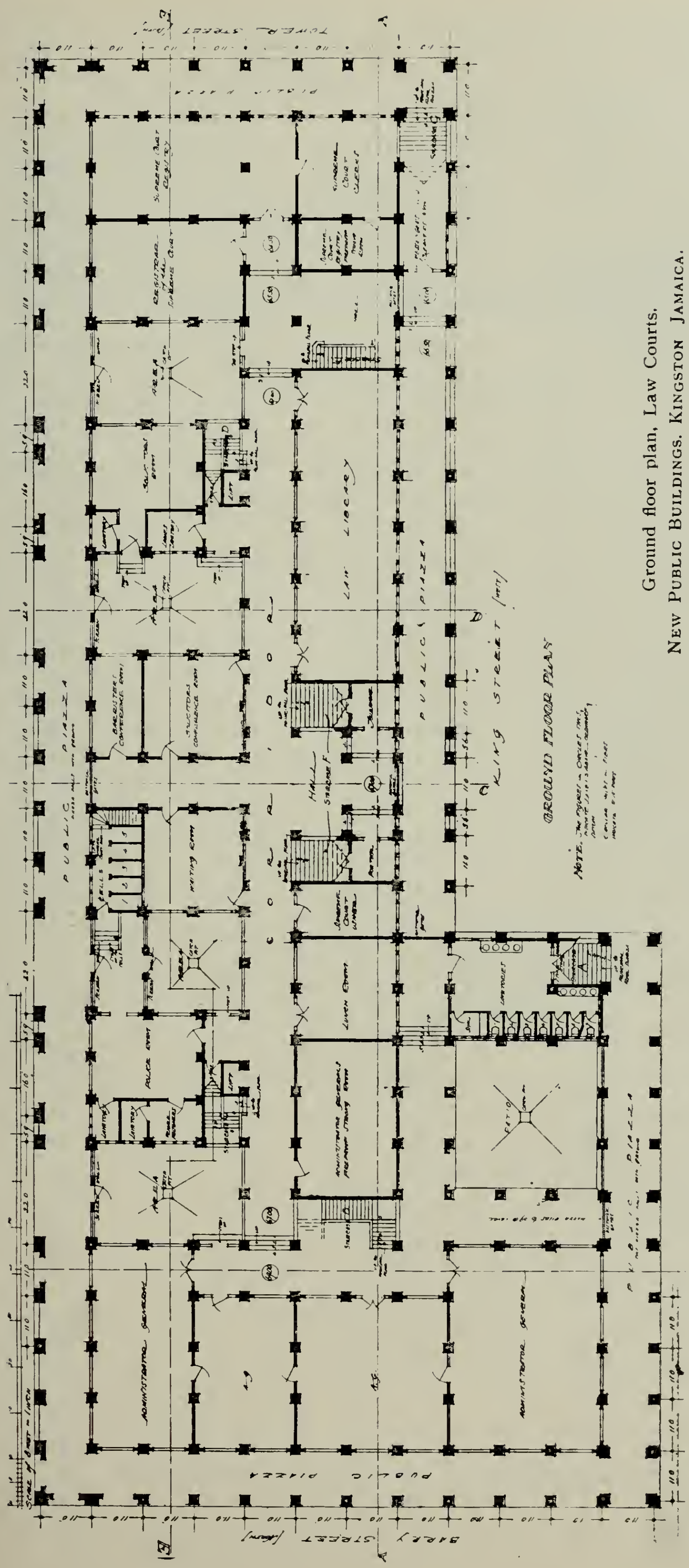
24 in. by 24 in., and in the upper floors 18 in. by 18 in. The average span of the beams supporting the floors is 20 ft., with a thickness of slab of 4 in.

The King's House was erected simultaneously with the above-mentioned public buildings, and, as shown in the illustration on page 87, the architectural design is of the same style as the one adopted for the larger building. In our issue of November, 1909, we gave a reproduction of a drawing hung at the Royal Academy of this building. The King's House is intended for the residence of the Governor of Jamaica.

A large swimming bath was also provided for, and there are several remarkably fine dancing and reception halls. There is a ground floor, principal floor, top floor, and flat roof; each floor measuring approximately 17,000 sq. ft.

The public buildings and King's House form part of the first contract, and the work was executed on the Coignet system of reinforced concrete by Messrs. Cowlin & Son, of Bristol.

The new Law Courts, which are very similar in appearance to the public buildings above described, form the object of a new contract which has recently been let to Messrs. Mais & Sant, of Kingston, Jamaica. They are designed on the same



Ground floor plan, Law Courts, New Public Buildings, Kingston Jamaica.

principle. They are now in course of construction, and plans of the ground and principal floor of this building are shown on pages 93 and 94, the principal elevations being given on page 92.

We hope when this building is completed to give views of the finished structure.

The first contract was placed in open competition between the various systems.

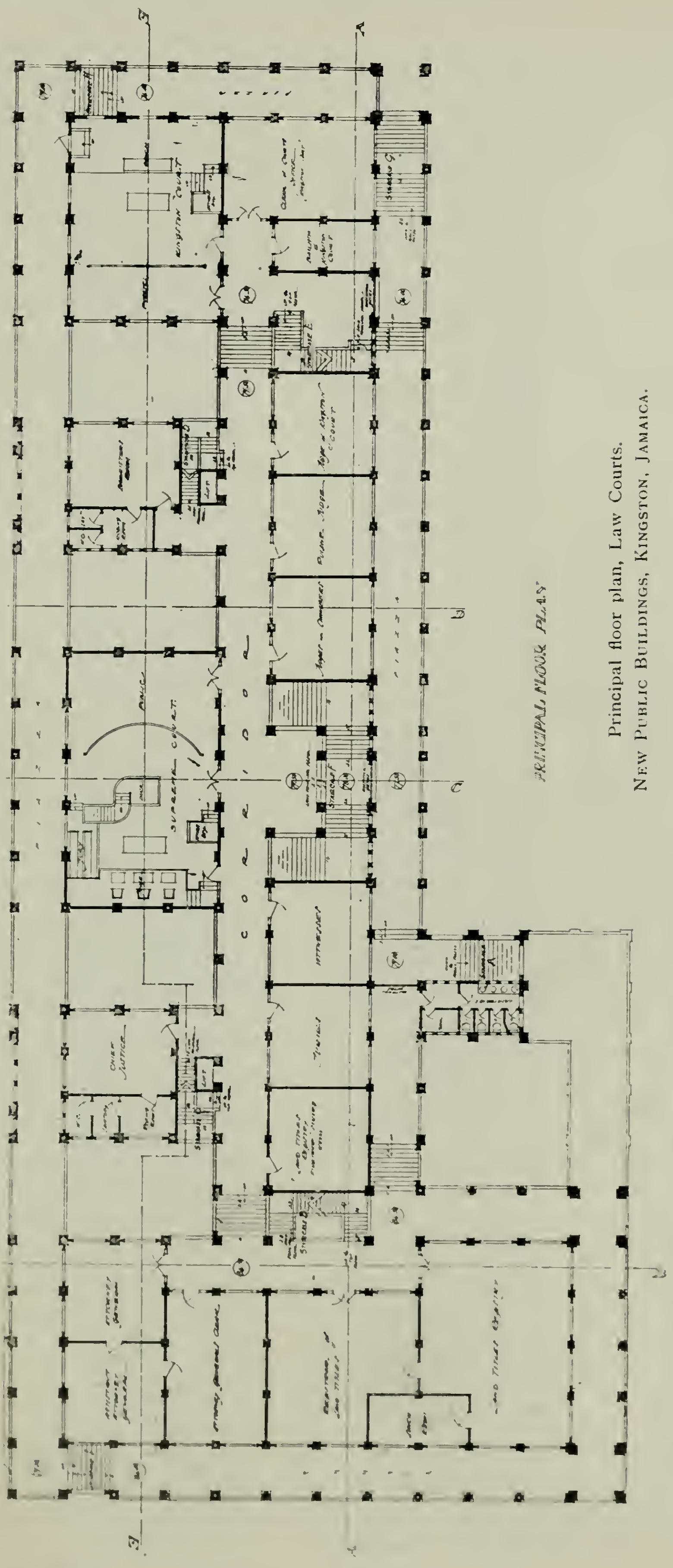
For the second contract, however, the Coignet system was specified exclusively by the architects on behalf of the Jamaica Government, and a certain number of contractors thoroughly acquainted with the erection of works in reinforced concrete were invited to tender.

All these buildings afford a striking example of the development of reinforced concrete in the Colonies; the advantages being economy over ordinary materials, resistance to earthquakes and fire.

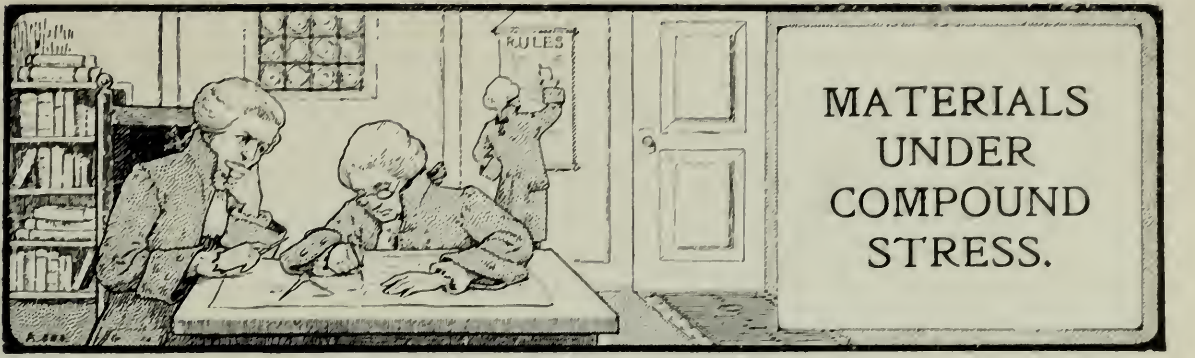
It may here be stated that the Coignet system of reinforcement is composed of plain round bars of mild steel. The pillars are constructed by means of vertical bars bound together by spiral hooping of small diameter, and the framework of the beams is composed of top and bottom bars united together by means of stirrups.

The work was entirely carried out by natives under skilled supervision, and there does not appear to have been any difficulty in its execution.

The cement used throughout was the "Ferrocrete" brand, supplied by the Associated Portland Cement Manufacturers.



Principal floor plan, Law Courts.
New Public Buildings, Kingston, Jamaica.



MATERIALS UNDER COMPOUND STRESS.

The Effect of Recent Investigations upon Working Stresses for Shear.

By EWART S. ANDREWS, B.Sc.Eng.[Lond.].

DURING the past few years several investigators have attacked the problem of the strength of materials under compound stress, such as the stresses produced by a combined bending and torsion, as in the case of an overhung crank-shaft. The results of these experiments have been in very good general agreement considering the difficulty which always exists in getting consistent results with work of this nature. For mild steel these experiments seem to prove this the "resultant shear-stress theory," or, as it has recently been called, Guest's law is the most correct one, and to fully appreciate this result we would do well to remind ourselves of the three theories which are generally known with regard to compound stresses in elastic materials. They are :

1. Principal stress, or Rankine theory.
2. Maximum strain or St. Venant theory (sometimes called French theory).
3. Resultant shear stress, or Guest theory.

We will compare the formulæ by the aid of the following notation :

f = Tensile or compressive stress } forming the compound stress.
s = Shear stress } forming the compound stress.
Let F = Resultant tensile or compressive stress equivalent to the compound stress.
S = Resultant shear stress equivalent to the compound stress.

Then the various theories give :

1. Rankine. $$F = \frac{f}{2}\left(1 + \sqrt{1 + \frac{4s^2}{f^2}}\right)$$

2. St. Venant. $$F = \frac{f}{2}\left(\frac{3}{4} + \frac{5}{4}\sqrt{1 + \frac{4s^2}{f^2}}\right)^*$$

3. Guest. $$S = \frac{f}{2}\sqrt{1 + \frac{4s^2}{f^2}},$$

Now, according to which of these methods is taken as correct we obtain the following results with regard to the relative values of the safe working stresses, f_T and f_S, in tension and shear respectively to use in practice :

1. Rankine, $f_T = f_s$
2. St. Venant, $f_T = \frac{5}{4} f_s$
3. Guest, $f_T = 2 f_s$

These results are obtained by putting $f = o$ in cases (1) and (2) and $s = o$ in case (3).

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* This is for Poisson's ratio $= \frac{1}{4}$.

It will be noted in passing that (2) is the rule usually adopted in practice for determining working stresses. This is very strange, seeing that nearly all the text-books give Rankine's theory as the correct one to use in the before-mentioned case of the overhung crank-pin.

It is very doubtful if practical engineers have fully appreciated the importance of these experiments from this point of view as working stresses. *If Guest's law is finally accepted as most nearly correct—and it seems at present that this is inevitable—then in designing structures our shear stress should be one-half of the tensile stress.* At present the figures most commonly used for dead loads on mild steel are 7 tons per square inch in tension and 5 tons per square inch in shear—that is to say, the shear stress is, on the Guest theory, $1\frac{1}{2}$ tons too high—*i.e.*, over 40 per cent. too high. This aspect of the question appears to have been appreciated fully only recently.

Guest's experiments were carried out in America for combined bending and torsion and combined tension or compression and internal pressure, and were published in about 1900, tubes being used ; Professor Hancock followed in 1906, in America, with tests on tubes and solid rods in combined tension and torsion ; Mr. Walter Scoble, B.Sc., published in the same year the results of experiments made in this country in combined bending and torsion ; and last year Assistant Professor C. Alfred Smith, of East London College, published the results of several experiments in combined compression and torsion, and Mr. Laurence B. Turner, B.A., of Cambridge, published the results of very careful experiments in pure tension and pure torsion. A good review of these various experiments will be found in *Engineering*, August 20th, 1909, by Mr. Smith, and February 5th and 12th, 1909, by Mr. Turner. All these experimenters favour the Guest theory, and as greater care is taken with the experiments the results get more consistent.

The procedure in each case has been much the same. Careful measurements have been made of the strains for various loadings with given proportions of tensile or compressive to shear stress, and by drawing a stress-strain diagram the elastic limit (or in the earlier experiments the yield point) is carefully obtained. The assumption is that the elastic limit will always occur at the same resultant stress or strain as the case may be, and so the equivalent stresses at the elastic limit are calculated according to the three theories, and the theory which gives the least variable result for the equivalent stress at the elastic limit for various ratios of tensile or compressive stress to shear stress is regarded as the most correct. The elastic limit—*i.e.*, the point where the stress-strain diagram ceases to be straight—appears to be the most satisfactory point to take, because the yield point is farther from the elastic limit in the case of variable stress such as occurs in beams and torsion of solid bars than in the case of simple stresses such as in a tie-bar. This point was brought clearly to the writer's notice in some experiments on crane hooks,* where the distance between the elastic limit and the yield point increases as the radius of the hook decreases, and the variation in the stresses thus increases. It is for this reason that the old beam paradox arose, and that it had not been noticed previously in torsion experiments that the stress at elastic limit is one-half of that in tension for the same material.

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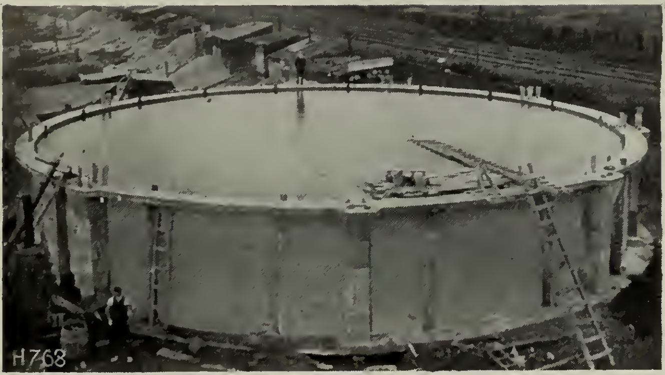
* See, for instance, Drapers' Company Research Memoirs, Technical Series I., and a paper by Prof. Goodman, Proc.I.C.E., Vol. CLXVII. ; also a paper by Prof. Rautenstrauch in the *American Machinist*, October, 1909.

The acceptance or rejection of these results by practical designers as affecting the determination of working stresses rests upon whether or not they accept the proposal to fix the working stresses from the elastic limit instead of the breaking stresses. There are, of course, arguments in favour of both methods, but it seems that the elastic limit method must prevail in the end, although the inertia still to be overcome is tremendous. Advocates of this method are exceedingly pleased to see that the reinforced concrete construction has brought this point to the fore, because, of course, as soon as the steel has exceeded its elastic limit it stretches more quickly and throws a much higher stress on to the concrete. It is now, therefore, quite common to find the stresses in tension of the steel specified in terms of the elastic limit.

This question of working stresses is one which presents some difficulties, but it is of the utmost importance if constructional design is to be put upon a scientific basis ; and it is to be hoped that the experiments above referred to will be freely discussed, and that, if their results are accepted as more nearly true than theories which have previously held their ground, practical designers will use them in determining their working stresses.



REINFORCED CONCRETE GASHOLDER TANK AT LEIGH-ON-SEA.

By CHAS. F. HUNT,
Assoc. M. Inst. C.E.

Our description of this Gasholder Tank is taken from a paper read at a meeting of the Association of Municipal and County Engineers by Mr. Chas. F. Hunt, who also supplied us with the particulars of the tests carried out.—ED.

THE first reinforced concrete gasholder tank in the United Kingdom was recently constructed at Leigh-on-Sea. As the site is on reclaimed foreshore, and is impregnated with salt water, a steel tank would have had to be protected with concrete, and as the cost of this would have been very high, it was decided on the recommendation of the Surveyor to the Council (Mr. J. W. Liversedge) to adopt reinforced concrete.

The tank is 64 ft. in diameter by 29 ft. 6 in. deep. The wall of the tank is 8 in. thick at the bottom and 4½ in. thick at the top. The capacity of the tank is 538,000 gallons. The holder, for which the tank is required, has two lifts and a capacity of 160,000 cu. ft. The guide framing has nine standards, which are fixed on reinforced concrete buttresses incorporated with the tank.

Inside the tank there are eighteen channel iron guides secured to the concrete wall with bolts. The wall is strengthened at these places with reinforced concrete buttresses.

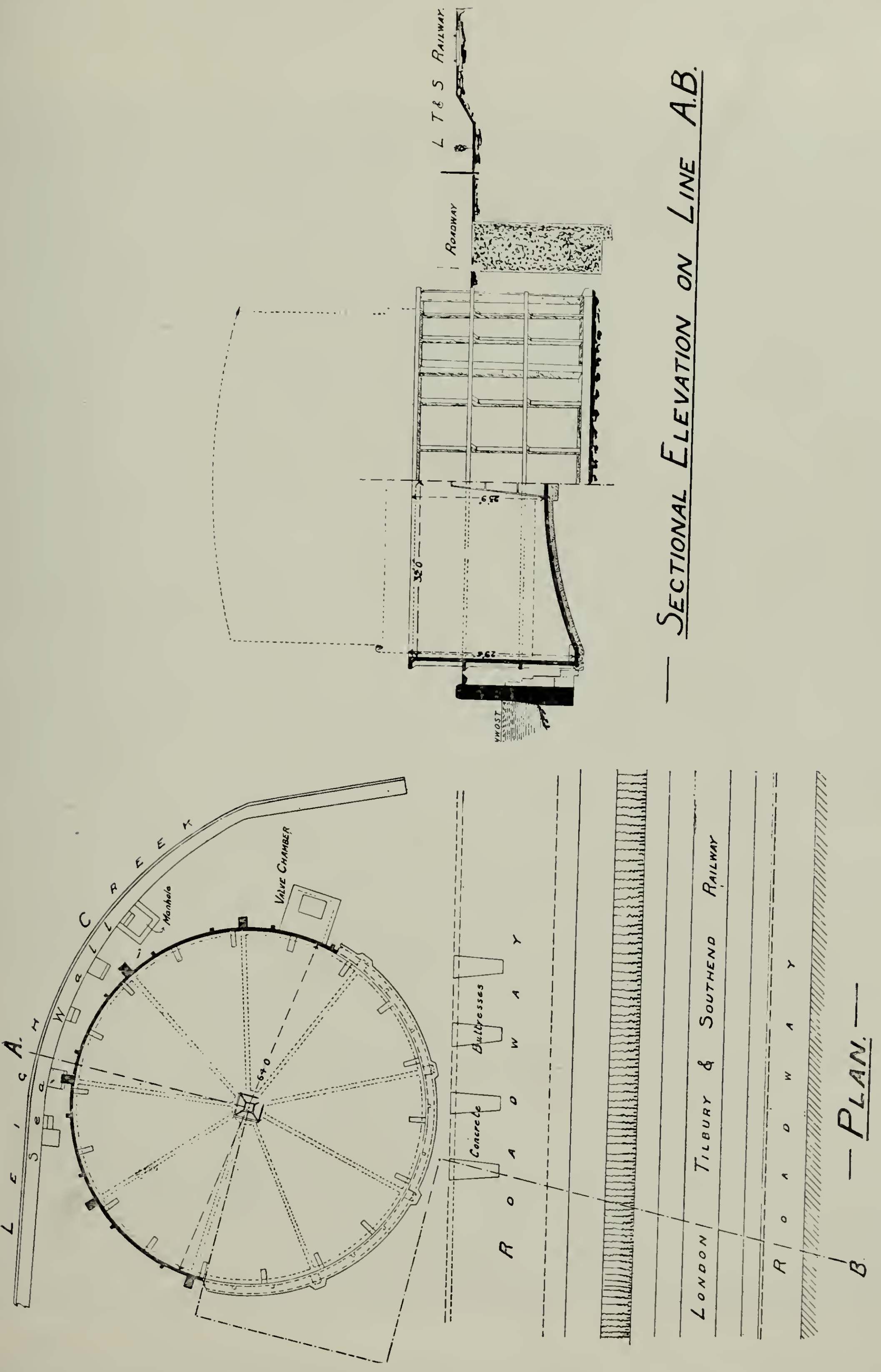
DESIGN.

The design of the tank is as follows :—

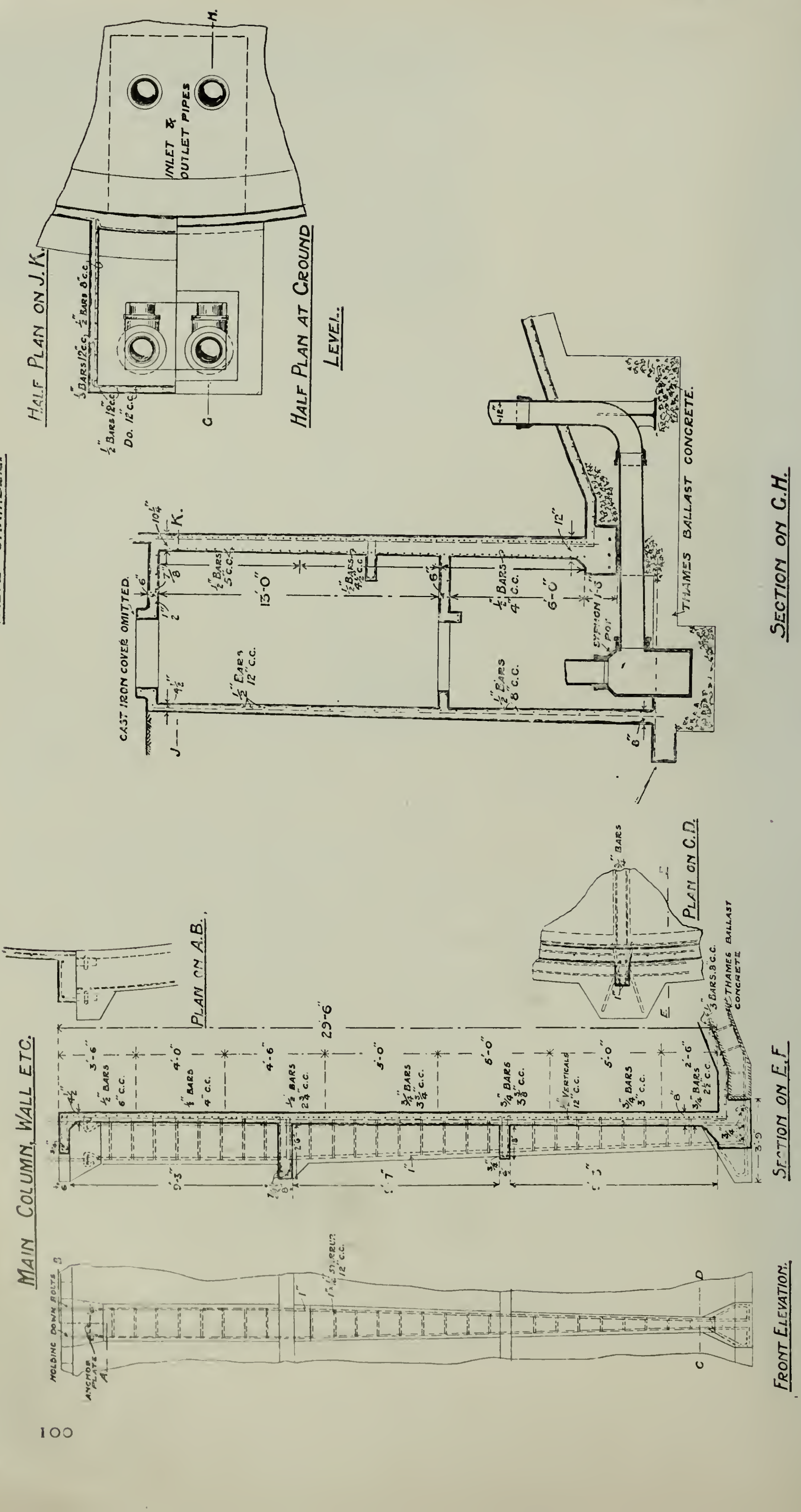
A foundation slab of 5 to 1 Thames ballast concrete, 12 in. thick, is laid over the site of the tank to within 7 in. of the inside face, to distribute the weight evenly, and to provide a firm, clean surface on which to lay the reinforced floor slab, which is 6 in. thick. The weight of the wall and main and secondary columns is carried by a circular beam, 2 ft. 3 in. wide by 1 ft. 6 in. deep, which is reinforced by three ¾-in. rods. The wall itself is 8 in. thick at the base, and tapers to 4½ in. thick at the top, immediately under the balcony. The reinforcement consists of ¾-in. bars spaced from 2½ in. centre to centre at the bottom to 3¾ in. at 17 ft. 6 in. above floor level. Above this height ½-in. bars spaced from 2¾ in. to 6 in. are used. For the whole height of wall vertical ½-in. rods are used at 12 in. centre to centre. The ¾-in. bars have 4 ft. lap and the ½-in. bars 3 ft. lap.

The main columns, of which there are nine, carry the standards to the guide framing. At the top (for the purpose of giving room for holding down bolts) they are set out with the vertical rods 19 in. centre to centre radially, and 15 in. circumferentially. The columns are vertical down to the ground line, below which they taper both ways, to 12 in. by 8 in. immediately above the circular foundation beam. The reinforcing rods are 1 in., and one pair is shaped and turned outward to form a shoe to spread the load over a greater area of ground.

The secondary columns, of which there are eighteen, are placed to correspond with the channel guides, which are fixed to the inside face of the tank, thus materially stiffening the tank wall at these places. These secondary columns project 12 in. from outer face of tank, and are reinforced by two ¾-in. bars. Belts of depths 6 in.

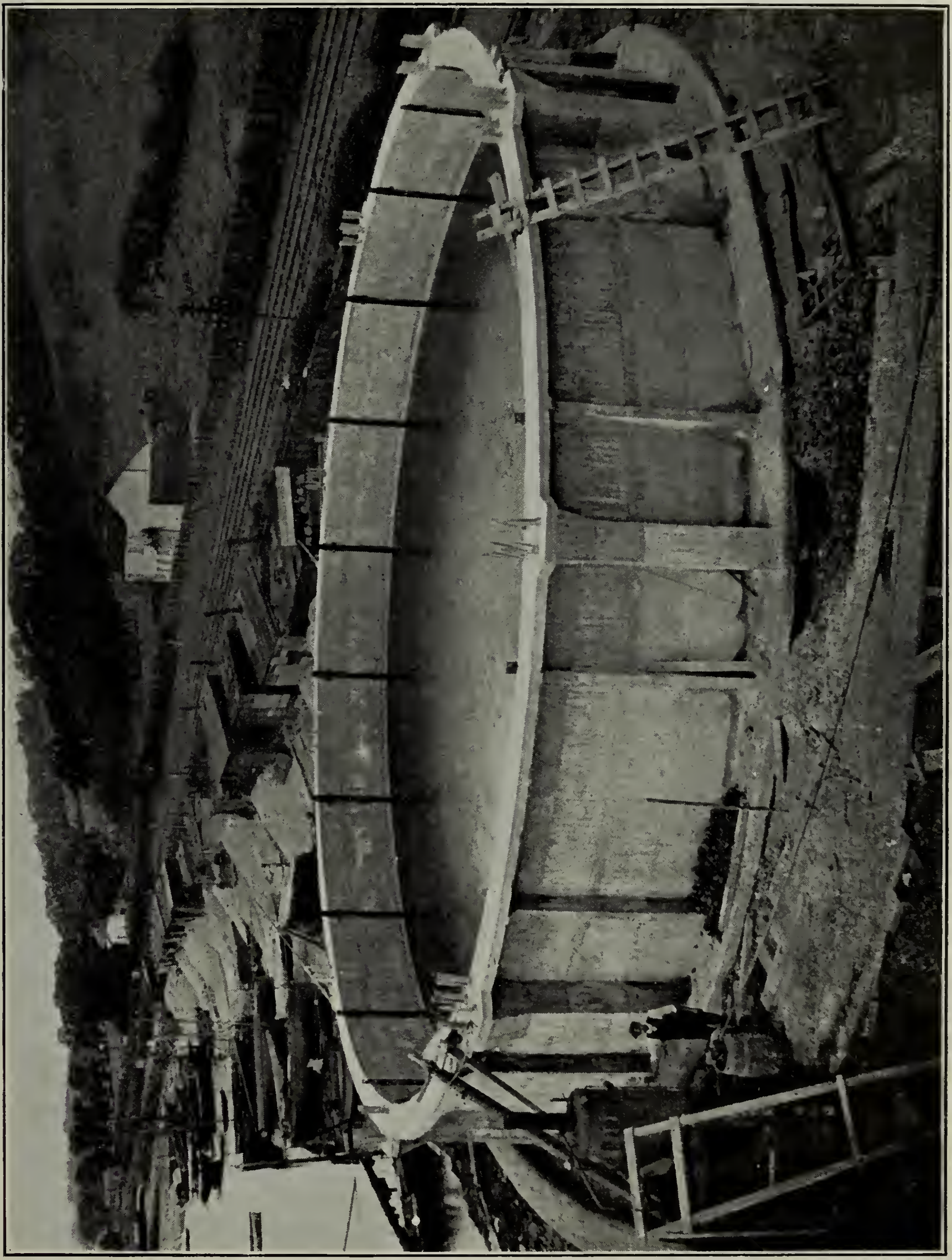


Plan and elevation.
Reinforced Concrete Gasholder Tank, Leigh-on-Sea.



Details.
Reinforced Concrete Gasholder Tank, Leigh-on-Sea

and 8 in. encircle the tank at 10 ft. and 20 ft. approximately above floor level inside. They are respectively reinforced by two $\frac{3}{4}$-in. and $\frac{7}{8}$-in. bars. At the top of the tank a balcony, with a projection of 18 in., is constructed, reinforced with $\frac{3}{4}$-in. bars, and is widened at main columns where the guide frame standards are fixed. Stirrup irons are fixed in belts and balcony 12 in. centre to centre.



Reinforced Concrete Gasholder Tank, Leigh-on-Sea

In the floor are beams which radiate from the centre to the main columns. These beams are 9 in. wide by 12 in. deep, and are reinforced by two $\frac{3}{4}$-in. bars and stirrups fixed 12 in. apart. At the centre these beam rods are tied to a 1-in. ring.

The valve chamber is constructed with walls 8 in. thick at base, reducing to 4½ in. at ground level. The chief point of interest is the thickening of the tank wall by 4 in., and the provision of ½-in. bars at distances varying from 4 in. to 5 in. centre to centre. This will resist any tendency of the tank wall to act as a beam instead of as a boiler shell, between the rigid abutments of the valve chamber walls.

CEMENT AND CONCRETE.

The cement used in the work was the "Ferrocrete" brand, supplied by the Associated Portland Cement Manufacturers (1900) Ltd. The special feature of this cement is its soundness, for, as the name indicates, it is made principally for reinforced concrete work.

For the first portion, where quickness was a consideration owing to the wet weather and the nature of the ground, a quick-setting cement was used, but later a slower kind was adopted. Sometime before the work commenced, test cylinders of various thicknesses were made and put under pressure from a head of water of 30 ft., and kept so for a considerable time; for a short time they sweated, but soon became bone dry.

The concrete was mixed by hand in the proportion of 1 cement, 1½ sand, and 3 ballast. It was mixed wet, and when put into the walls was well worked between the bars with thin rammers. In joining up new work with work already executed, the old face was hacked rough and well grouted with neat cement grout.

CONSTRUCTIONAL DETAILS.

When the work of excavation was proceeded with, the boulder clay was found at a higher level than was anticipated, and advantage was taken of this to avoid a considerable amount of excavation by leaving a dumpling in the middle in place of the flat bottom originally intended. The dumpling was shaped out, and the 12-in. foundation slab formed of Thames ballast and cement in the proportion of 5 to 1, was put in, radiating channels being left for the beams.

The column bars, beam bars, and the three bars in circular beam were then put in with concrete under them. The circular beam was brought up to the level of the top of foundation slab. The floor slab and the radiating beams were then put in with ⅓-in. bars at 8-in. centres circumferentially and radially, embedded in the former. These bars overlap the radial beams by about 1 ft. 6 in., thus getting a good bond between the various sections of floor slab.

The whole of the bars used were of indented steel, with an elastic limit of 22 tons, an average of three tests giving 22·29 tons per sq. in.

The chief difficulties met with in carrying out the work were connected with the railway on the north side and the sea wall on the south. To cope with the first, four concrete buttresses were put down before the work on the tank itself was commenced. The buttresses were 12 ft. from back to front, 4 ft. wide on front face, and 3 ft. at the back. They are reinforced with a 1-in. diameter steel rod at the back, and have pot holes to form a heel to resist any sliding tendency.

Bolts were fixed in readiness for attaching walings when the work of excavation to the tank was proceeding. This was done, but the pressure on the walings was such that one or two of the bolts drew out. This was due to the abnormally wet weather, and probably to an old disused drain running in the roadway, which caused an accumulation of water behind the timber, and necessitated cutting holes in the buttresses to receive the ends of the walings. In such a position as this no risks were permissible, and to make assurance doubly sure further strutting was put to walings between the buttresses. When the wall reached the height of the struts, and filling had been put in and well watered and rammed, they were removed. The removal was effected with no movement of the material behind the walings.

During the progress of the works close observations were made in the following manner : A line was run through approximately parallel to the face of the buttresses and measurements taken from time to time. These proved that the buttresses were absolutely stationary. Levels and measurements were taken on the railway every day, generally twice per day, and no movement of any importance was found.

TESTS.

The tank was completed on June 9th, and testing was begun on July 6th following.

When the water was standing 10 ft. deep in the tank the age of the newest portion actually submerged was 64 days.

With the water at this level gauging was commenced, but water had been standing in the tank for several days, as it was only during constantly shortening periods about high water that the filling could proceed by gravitation. No doubt the fact that the water had been standing in the tank for several days accounts for the gauge showing no drop in water level, as absorption and " sweating " had ceased.

With 21 ft. head of water in the tank four trickling leaks were discovered. With one exception these were caused by the bolts used to secure the channel iron guides. The bolts were cut out where necessary and refixed, and the other slight leak at a horizontal joint was made good. The series of gaugings at 21 ft. deep show plainly the decrease in absorption after the concrete has been submerged for some time.

On July 27th it was found that with the water 29 ft. 3 in. deep in the tank the loss was slightly under $\frac{1}{8}$ in. in 12 hours, and the tank was then emptied. While in this condition it was subjected to external water pressure of 10 ft. head. This was done by opening valves in the sea wall and admitting sea water to the site.

It was then found that there was a slight leakage, and on gauging it was estimated that this would account for the slight loss noticed when the tank was full. When the steel contractor's work was sufficiently advanced to leave the tank bottom clear these leaks were made good.

The sweating which took place above ground level was not sufficient to cause water to trickle down the wall, but was confined to patches of dampness, but after a short time this dampness entirely disappeared.

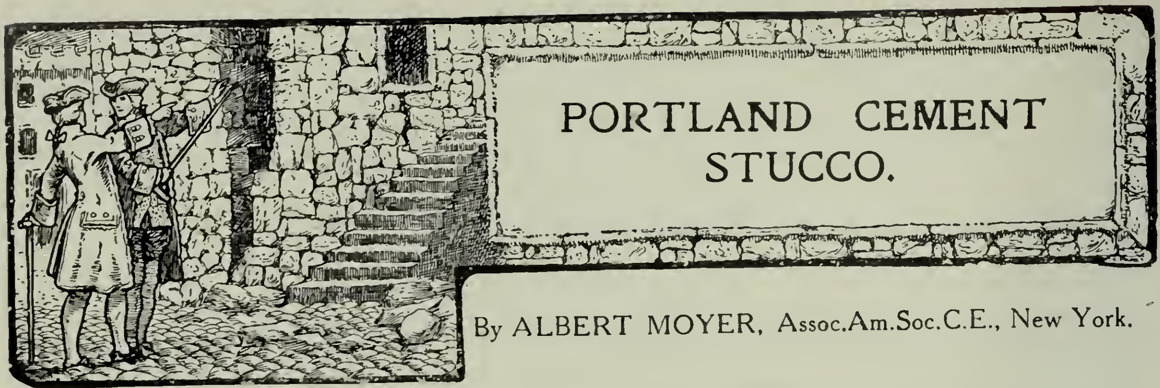
The amount of sweating was less in the case of the tank than in several test cylinders with 4-in., 6-in., and 8-in. walls, which were subjected to water pressure under a head of 30 ft. These cylinders were made of material similar to that used in the tank, and were made under the most favourable conditions.

The gasholder was completed and put into use on December 18th, and the tank has given every satisfaction. This good result is no doubt due to the great care exercised during construction.

The success of this tank, near a railway on which run heavy express trains, shows that, in spite of vibration, a concrete tank can be made watertight without rendering the internal surface.

The tank was designed and constructed by Messrs. Lewis Rugg & Co., of Queen Anne's Chambers, Westminster, under the direction of Mr. J. W. Liversedge, Assoc.M.Inst.C.E., engineer to the Urban District Council of Leigh-on-Sea, to whose requirements the original design was amended, and under whom the writer had charge of the work.

The whole of the reinforcement was supplied by the Patent Indented Steel Bar Co.



PORTLAND CEMENT STUCCO.

By ALBERT MOYER, Assoc.Am.Soc.C.E., New York.

In view of the necessity for giving an attractive exterior finish to concrete and reinforced buildings, the following article on Portland Cement Stucco for exteriors should merit attention.—ED.

The history of stuccoes does not furnish sufficient information and data to be of practical value in the manufacture of the present-day Portland cement stuccoes. There are existing records of 350 B.C. of stuccoes made from vastly different material than are of economical use at the present time, and we find that such stuccoes were almost invariably used in the warm climates where the action of frost would not tend to disintegrate the rather poor material which was then available.

There is every reason to believe that originally these stuccoes were intended to cover up and protect inferior building stone and sunburned straw brick. The archæology of stucco would tend to show that, from an artistic standpoint, this method of decoration was a development of the wattled buildings, which were plastered with clay and different muds hardened by being baked in the heat of the sun. Therefore, in this instance, the use of clay plaster over wattled houses was to protect an inferior building material.

To-day stucco is used for a similar purpose, that of protection and pleasing surfaces. It would, therefore, seem advisable to recommend a material which would best serve the purpose of protection and artistic merit. Stucco or plaster should never be used as an imitation of other building material.

To carry out these ideas I would recommend only Portland cement stucco for exteriors, as this is the only hydraulic material which will stand the action of the elements.

From the artistic side the writer would also recommend such surface finish for stucco as will cause both natural colour and pleasing texture. It would be well, therefore, to expose to view the aggregates used, and avoid as far as possible exposing the bonding material, Portland cement.

There is no artistic reason for allowing only the bonding material to be displayed to the eye. On very large jobs the surface can be cleaned off by means of a sand blast, and on smaller jobs the surface may be cleaned, exposing each grain of sand by means of muriatic acid in dilute solution, 1 part commercial muriatic acid, 4 to 5 parts clear water.

Where white aggregates are used the surface may be cleaned off with a solution of sulphuric acid, 1 part acid, 4 to 5 parts clear water. The sulphuric acid leaves a white deposit and therefore should not be used excepting where the aggregates are white.

Another method is to scrub the surface while yet green, say, within 24 hours, with a scrubbing brush and clear water. This is more difficult than the others, for the reason that if the stucco is allowed to remain too long before scrubbing it will be too hard to remove the coat of neat cement from the outside of each particle of sand or other aggregates; and if scrubbed when it is too soft the surface may be damaged and difficult to repair.

If the character of the available aggregates will not present a pleasing surface when exposed, the following surface treatment may be used :

While the last coat is still thoroughly damp, apply a Portland cement paint composed of 1 part Portland cement, 12 per cent. of the volume of the cement of well hydrated lime, pulverised form, and 1 part of the volume of the cement of fine white sand. Mix with water to the consistency of cream or the ordinary cold water paint. Stir constantly and apply by using a whisk broom throwing the paint on with some force.

Keep this finish surface damp for at least six days or longer if economy will permit. Do not allow it to dry out in any one place during the week. If necessary protect by hanging tarpaulins and using a fine spray of water playing on several times during the day by means of a hose. This will give a pleasing light grey colour of excellent texture.

Stucco may be applied to various building materials. There is hardly any reason at the present time for stuccoing stone buildings, the procedure at best is difficult and hardly to be recommended. Our building stone is usually an excellent material and, therefore, does not require either protection or covering to produce pleasant effects.

New brick may be covered with stucco very successfully. The joints should be first raked out half an inch and the brick saturated with water. It is always best to start stuccoing at the top of the wall, and work down between the pilasters or corners, finishing a whole strip or whole side wall from top to bottom in one day. Thus no streaks or cracks are formed where one day's work ends and another begins. By this method the wall can be kept wet ahead of the work by means of a hose.

The second coat should be put on as soon as the first coat has stiffened sufficiently to hold in place and stand the pressure of the trowel. This second coat should be well scratched and the finished coat applied while the second coat is damp. The finish coat should then be kept wet, protected from the rays of the sun, and as far as possible from drying out. This can be done by hanging wet cloths over same. This rule of keeping each coat moist until the other coat is applied, and protecting after applying the finish coat, must be observed in all forms of Portland cement stucco.

If the stucco is to be applied to metal lath or wire cloth the metal should be plastered on two sides so that it is entirely encased in mortar in order to avoid rusting. If this is impracticable then the metal lath or wire cloth should be dipped in a paint made of equal parts of neat Portland cement and water. Immediately after dipping, the metal lath or wire cloth should be tacked on to a frame in the position it is intended to occupy. As soon as the neat Portland cement has hardened on the metal, apply the first coat of stucco. Hair should be added to the mortar to be applied on wire mesh or expanded metal. One bag of cement, one pound of hair.

If plaster boards are used they should be nailed on the framework of the building, leaving at least a quarter of an inch joint between each plaster board. This joint to be filled in with lime putty, otherwise each plaster board will cause square cracks on the outside of the stucco the size of each board.

A convenient method of waterproofing plaster boards is easily available. The boards may be painted with two coats of any of the reputable bitumen waterproof paints to which plaster adheres. Then about 24 hours after the bitumen paint has been applied, and within six days, apply the first coat of stucco.

For stucco on terra-cotta blocks great care should be exercised in keeping the blocks thoroughly saturated with water, for if the blocks are not saturated they will pull the water out of the mortar and it will crack and disintegrate. Portland cement requires water until it has thoroughly hardened, which ultimate hardening usually takes from 14 days to a month. It is not always necessary to play the hose on the wall for a month, although it would be advisable. The dews at night, the dampness in the atmosphere and the rain will furnish the necessary moisture, provided the material on which the mortar has been plastered has not too great an affinity for water.

In order to prevent the porous, hollow terra-cotta tile from sucking the moisture from the stucco, and also to furnish waterproofing and an additional bond other than that which would be given by the key, it is good practice to paint the surface of the dry terra-cotta blocks, after they have been erected in the wall, with two coats of bituminous paint. It is important that the first coat of stucco is placed over this paint after 24 hours and within six days.

Proportions for a good stucco should be 1 part Portland cement, 2½ parts coarse, clean sand. (If coarse, clean sand is not available, use only 2 parts of sand.) Add 10 to 15 per cent. of well hydrated lime, dry pulverised, of the volume of the cement.

If it is the desire of the owner or architect to use the exposed aggregate method, interesting natural colours can be obtained by using the following materials instead of sand, the same proportions—Green, red, buff, black or white marble screenings all passing a No. 8 screen and all collected on a No. 40 screen. These different coloured marbles and different coloured sand, where obtainable, can be used singly or in a combination. When exposed by scrubbing or the acid treatment very interesting results are obtained.

In mixing stucco great care should be exercised to obtain the thorough incorporation of cement, sand and the other aggregates. The sand and cement should be mixed together dry until an even colour results. This can be done by shovelling and raking while shovelling. Water should then be added, being careful not to add too much water at a time and not to get the resulting mortar too wet so that more sand or cement has to be added. Be very careful to bring the resulting mortar up to the proper consistency for plastering.

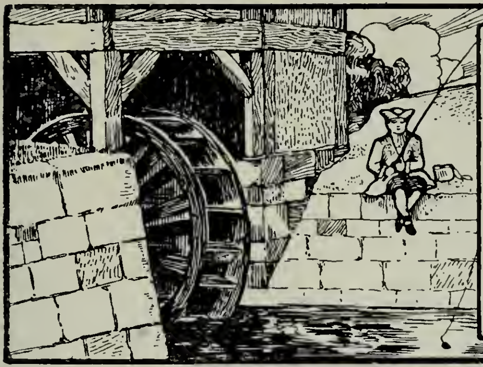
It is advisable to add to the mortar from 10 to 15 per cent. of the volume of the cement of well hydrated lime. This should be mixed dry with the cement and sand before the water is added. The addition of hydrated lime tends to fatten the mortar, making it more adhesive and impervious.

Another specification which we believe will prove of considerable value is by the addition of mineral oil to wet mortar. After water is added and thoroughly mixed with the mortar add 15 per cent. of mineral oil and remix. When the oil is to be mixed with the mortar it is always advisable to use hydrated lime, as we thus have a larger amount of emulsifying material.

The colour obtained by the scrubbing or acid method is limited only to the available sand or marble screenings, the colour will be the colour of the aggregates. An excellent green can be obtained by adding 8 per cent. of the weight of the cement of cromium oxide. This should be mixed dry with the sand, cement and hydrated lime.

Always keep in mind that the surface to which the mortar is to be applied must be thoroughly saturated with water, each coat of stucco must be kept moist, and the final coat must remain moist for at least one week or longer if economy will permit.

Stucco should not be trowelled to a smooth surface. The artist-painter would never think of smoothing the paint on his canvas by means of a straight-edge. Texture and colour are necessary if artistic results are to follow. By using the suggestions above outlined, the architect is privileged to select the aggregates from which the stucco is made, and has in fact as great play in the planning of the colour, tone and texture as the artist has in mixing the paints on his palette.



REINFORCED CONCRETE BARGES AND BOATS.

We have dealt in an early issue of this Journal with reinforced concrete barges and pontoons in Italy, and we are glad now to be able to give particulars of an example of this method of construction being used for a barge on the Thames. We also append details of a Canadian scow and a German motor launch of the same material.—ED.

While the employment of reinforced concrete for the construction of boats and barges is one of the most interesting applications of the material in the last few years, it is a peculiar fact that it was in this connection that reinforced concrete construction was first patented. In the year 1855 a Monsieur Lambot, a French contractor, took out a patent for the construction of parts of ships or boats in reinforced concrete, his method being to embed a wire meshwork in the concrete. His punt had been exhibited at the French Exhibition of 1853, and was afterwards put into service in a pond at his residence at Miraval, France, and was still in use a year or two ago, and may be so to-day.

Concrete at that time was made of hydraulic lime of a special kind, known in France as Vassy cement. The punt was of only slight thickness, and it is remarkable that it should have remained in use for so many years, being constructed of a cement which, although good, was not nearly so lasting as Portland cement.

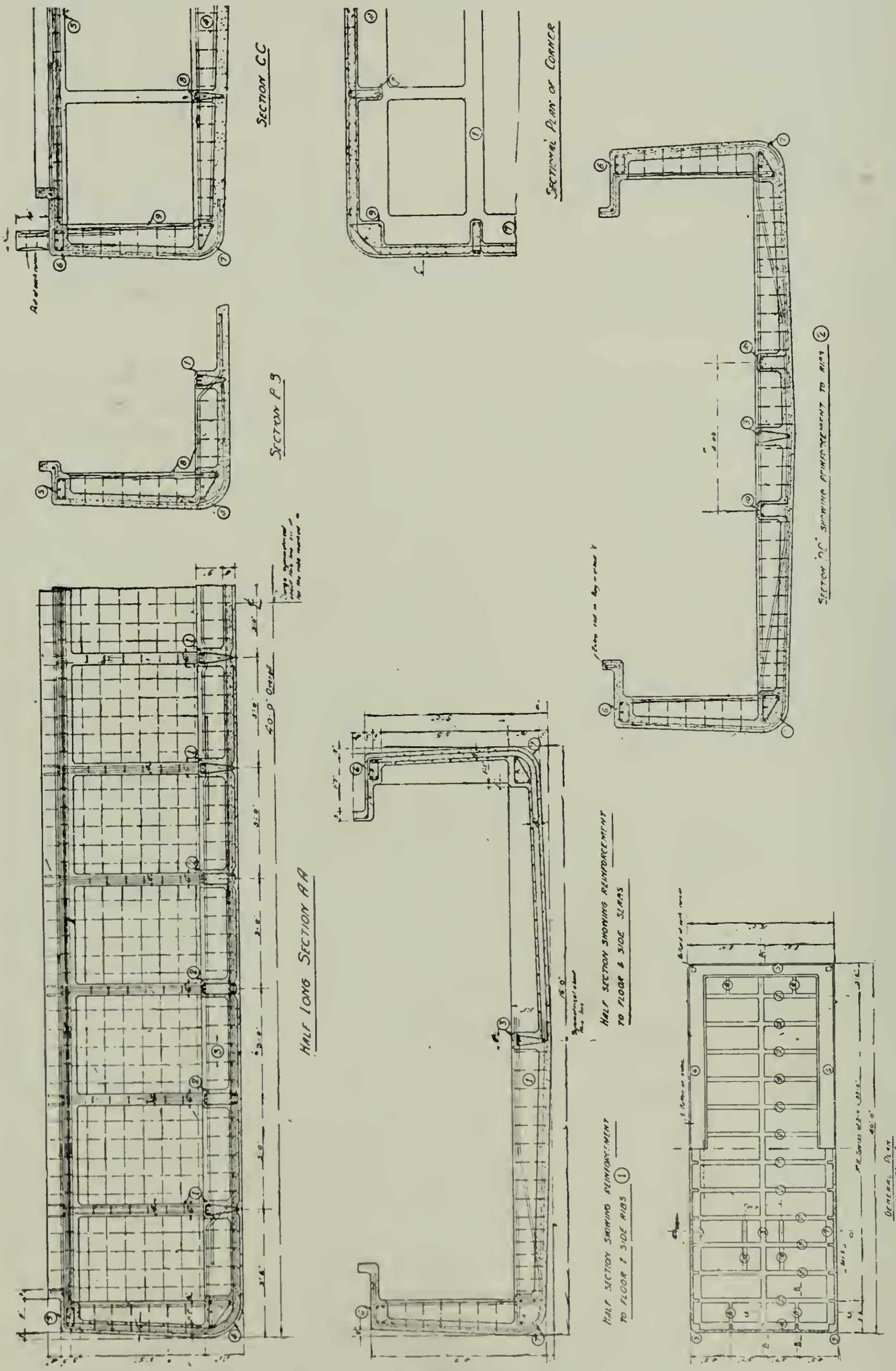
Nothing much seems to have been done with reinforced concrete for this purpose for a good many years, until some barges and pontoons were built about the year 1906 by the firm of Gabellini, of Rome, which were illustrated and described in our issue of March, 1908. This company still continue to build pontoons and boats of this material, which they have found very satisfactory. Another barge made of concrete reinforced with expanded metal, and constructed by the Expanded Metal Co.'s licensees in Italy, was described in our December, 1910, number.

The monolithic character of reinforced concrete gives great resistance, which is an essential quality owing to the rough usage these vessels get. They are also quickly constructed, economical, and fireproof. Any repairs are easily carried out, as it is generally only necessary to fill in with concrete or cement.

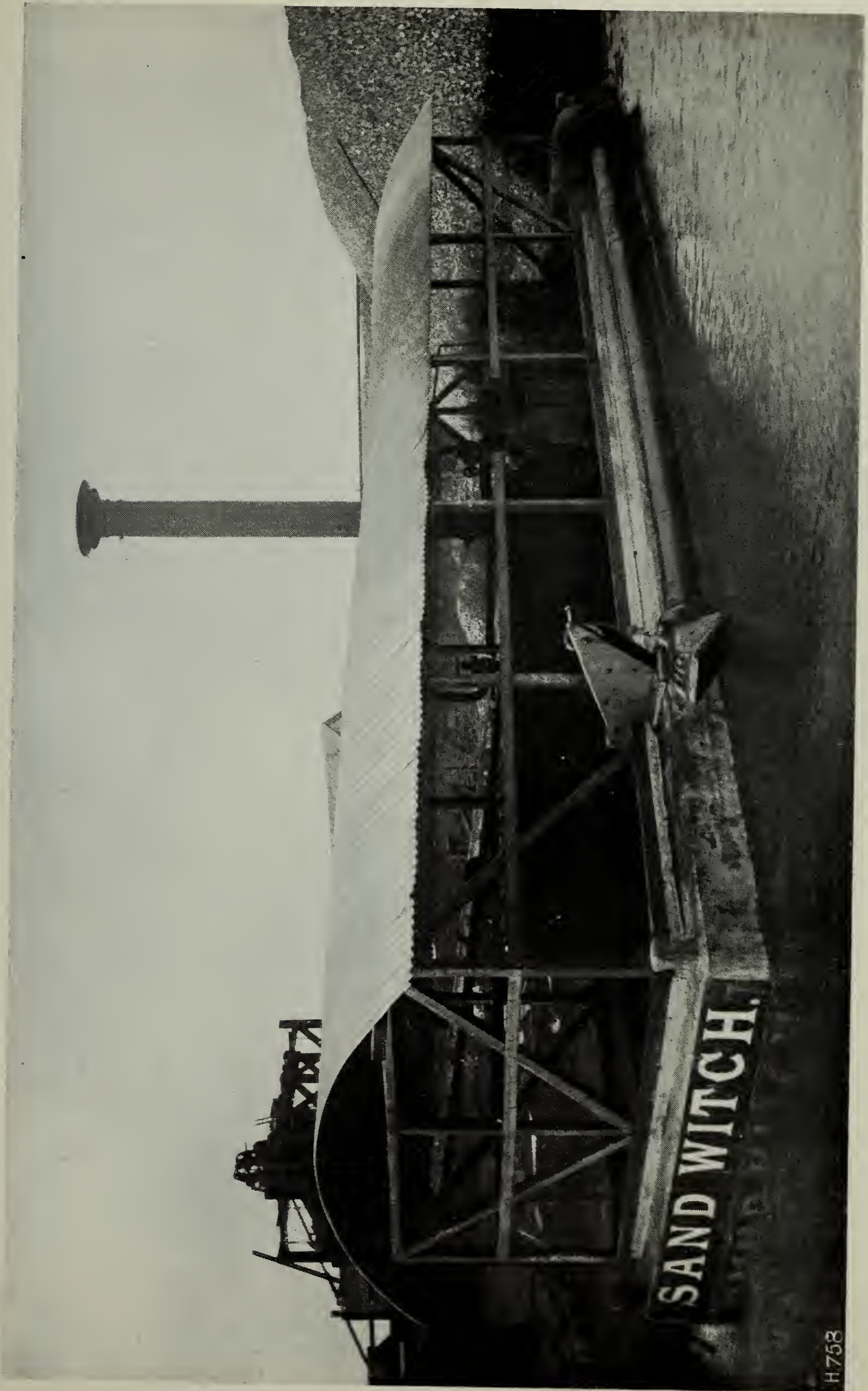
We now append details of some further applications of reinforced concrete for such work, the first example (particulars of which were submitted by Mr. Samuel F. Smith, M.E.) being English, and which is, as far as we are aware, the first instance of this material being used for such construction in this country.

REINFORCED CONCRETE BARGE ON THE THAMES.

It will be of interest to engineers, and perhaps to the shipping trade, to know that a barge to be used for dredging purposes has been constructed in reinforced concrete, and is now in operation at Ham, on the River Thames. The adoption of reinforced concrete in this instance is due to the engineering foresight of Mr. Herbert W. Anderson, A.M.Inst.C.E., coupled with the business enterprise of Mr. Brice, of the Ham River Grit Co. The design and construction of the work was placed in the hands of the Cubitt Concrete Construction Co., of 260 Gray's Inn Road, W.C., who carried the work through to completion within fourteen days of the date of laying the centering for the bottom slab. In four weeks from the date of finish a foot of water was pumped into the barge, and at intervals of three days an additional foot until it was full. The barge remained in this loaded condition for about a week, and then was passed as being sound and watertight and ready to receive the dredging machinery. As the work of construction was commenced early in September a


Section CC
Sectional Plan of Corner
Section P.Q
Half Long Section AA
Section 'CC' showing reinforcement to ribs
Half section showing reinforcement to floor & side slabs
Half section showing reinforcement to floor & side ribs
General Plan
40.0' Overall

Plan and sections.
Reinforced Concrete Barge on the Thames.



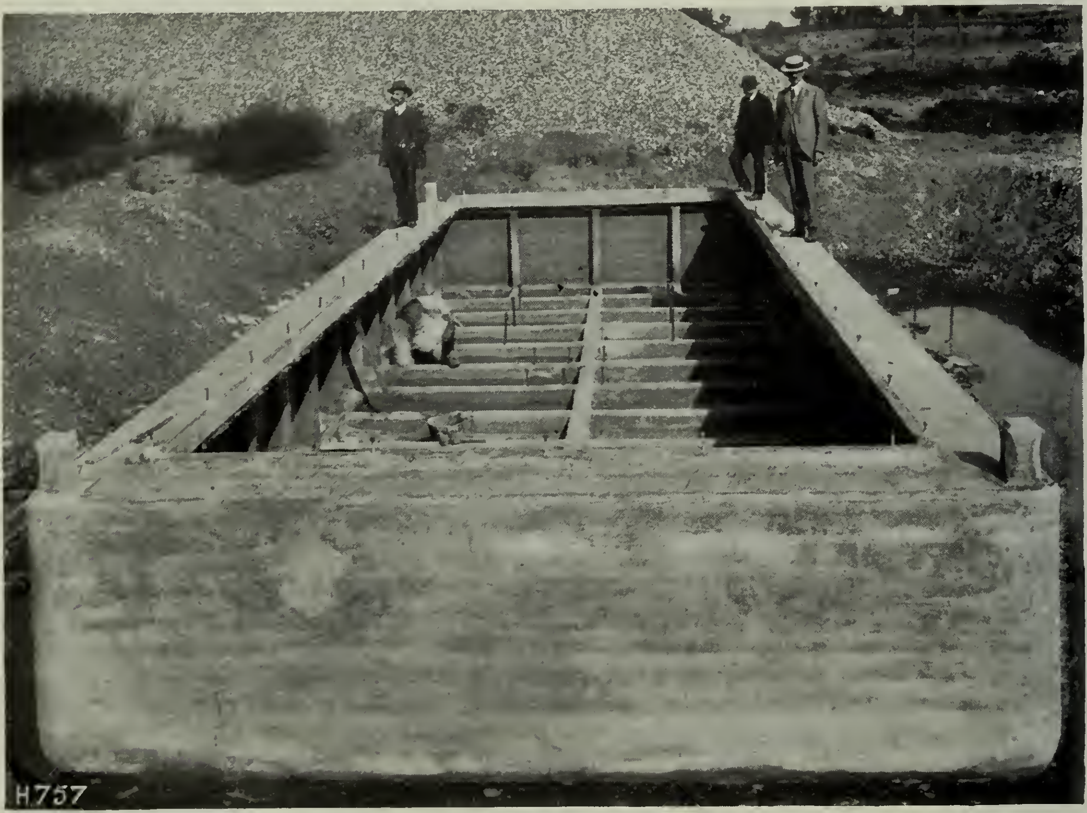
View of finished Barge.
Reinforced Concrete Barge on the Thames.

sufficient time has now elapsed to demonstrate the fact that the barge is a perfect success as to strength, fitness, and watertight qualities.

The ballast and sand used were supplied by the Ham River Grit Co., and the cement was the "Ferrocrete" brand, manufactured by the Associated Portland Cement Manufacturers. The ballast was of all sizes that would pass a ½ in. square mesh screen and be retained on a ¼ in., this being mixed with washed sand and cement in the proportions of :

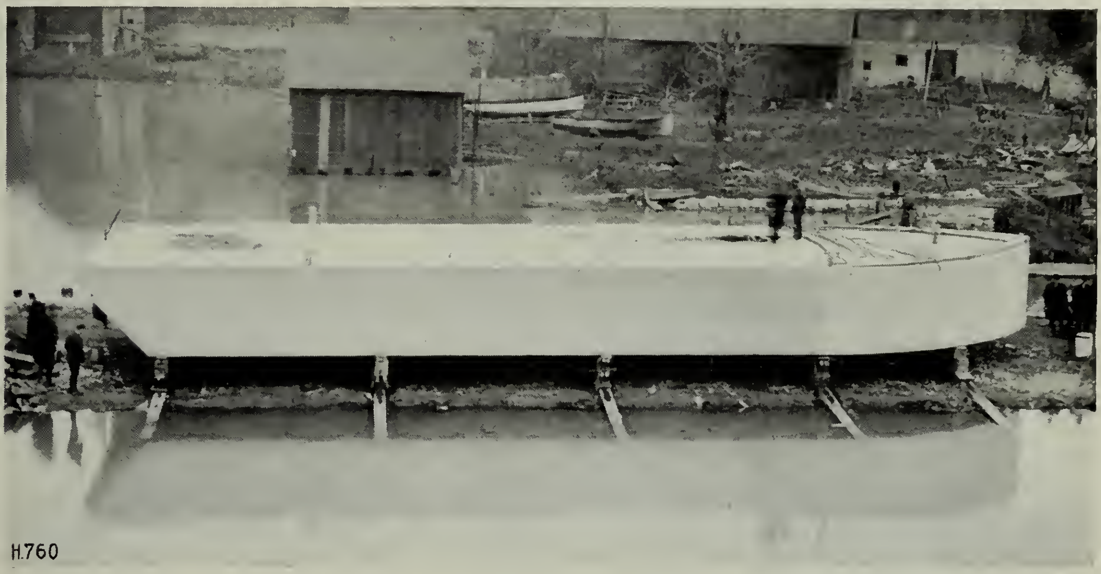
Ballast	27 cu. ft.
Sand	13½ ,,
Cement	7¼ cwt.

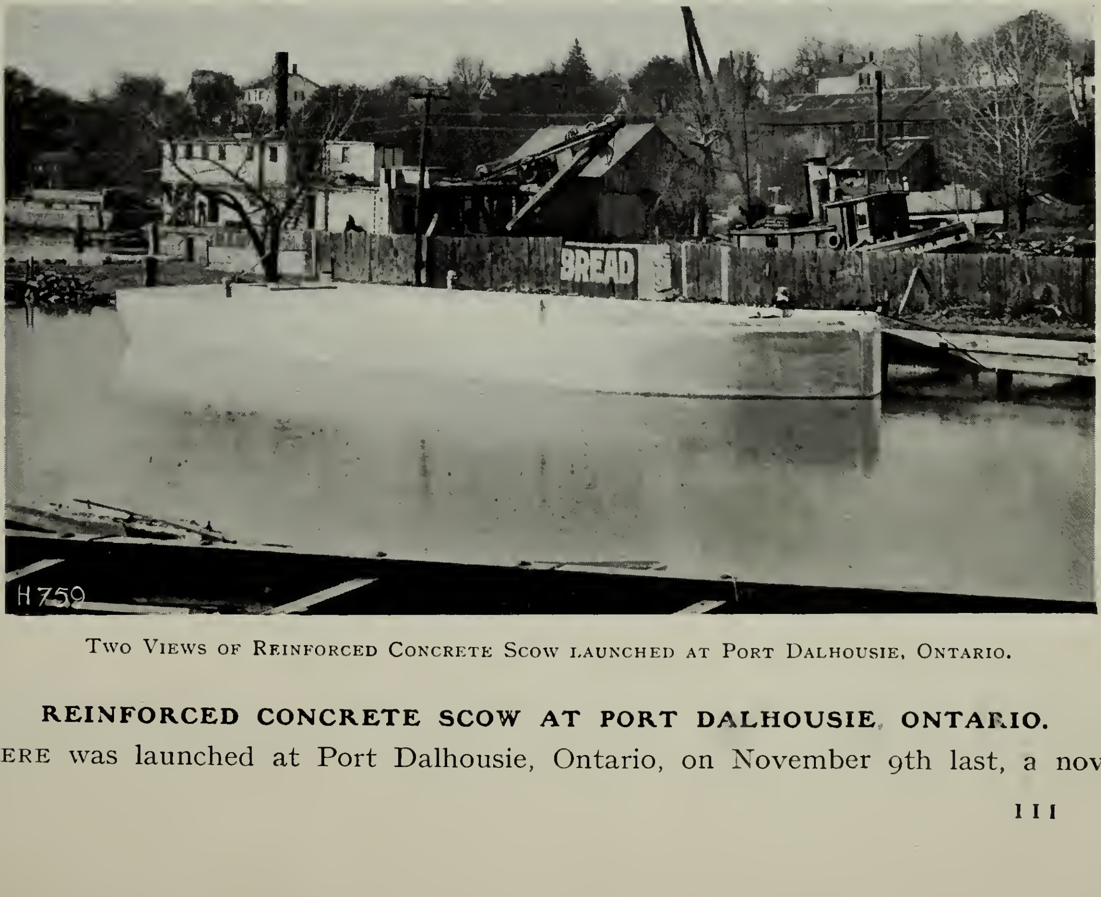
All the cement was treated with "Medusa" Waterproofing Compound in the proportion of 2 lb. to every 100 lb. of cement. As the barge is bone dry on the inside a striking example is here afforded as to the waterproofing qualities of this compound. The reinforcement throughout was of round rods of mild steel.



Hull ready for launching.
Reinforced Concrete Barge on the Thames.

It will be noted from the drawing that the form of the barge in cross-section is somewhat different from that usually adopted : as in this case there will be a considerable amount of bumping and ramming, it is desirable that the effect should be taken up on the bilge or bottom plane ; the sides therefore slope inwards, leaving the bottom portion to take the impact. It will also be noticed that there is no decking save for a narrow footway along the sides. As the space between the coamings is taken up by the machinery which extends above the deck level, there was no opportunity of spanning from side to side with bridges or cross-bracing to stiffen the barge longitudinally at the deck level. This, therefore, is accomplished by the vertical ribs being designed as cantilevers. The low freeboard is a requirement for the easy working of the dredging pipes. The deadweight of the barge works out to approximately 40 tons, and the weight of the machinery. etc., to about 20 tons. Having regard to the special nature of the work to be done the construction is somewhat heavier than would be the case if the barge was to be used for ordinary carrying purposes. From a point of cost the reinforced concrete materials are about the same as for a timber construction. The cost of manufacture, however is greater, but as experience is gained in this direction the expense will be materially lessened, and perhaps the final cost may be brought down to that of a barge of timber construction. From the point of upkeep it undoubtedly stands first, for no maintenance charges which are required for other forms of construction, whether of steel or wood, will be necessary.

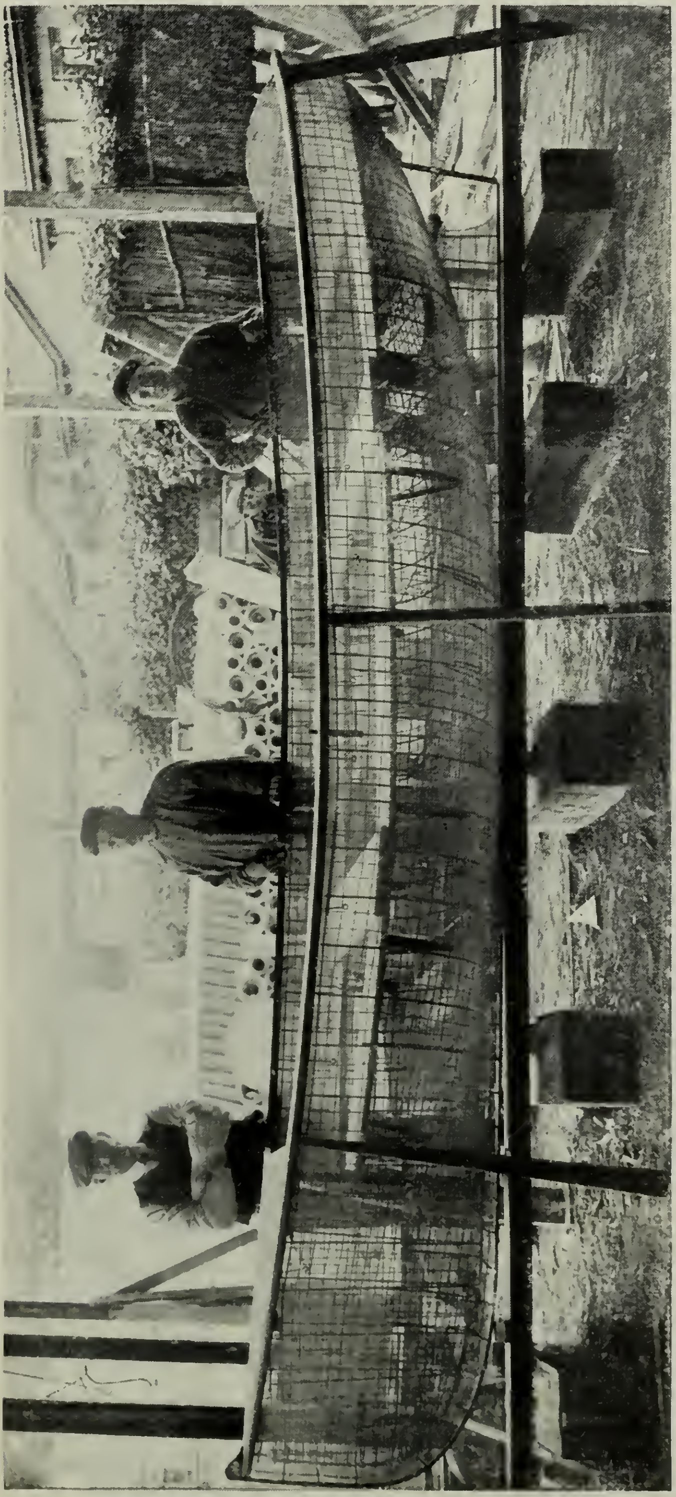




Two Views of Reinforced Concrete Scow launched at Port Dalhousie, Ontario.

REINFORCED CONCRETE SCOW AT PORT DALHOUSIE, ONTARIO.

There was launched at Port Dalhousie, Ontario, on November 9th last, a novel craft, constructed entirely of reinforced concrete, the largest of its kind yet built, and the first to be constructed in Canada. The vessel is a familiar type of deck scow, with flat bottom, rounded bow, and a square stern, with a rake to the latter, and was built for general use in the maintenance work on the Welland Canal. The over-all dimensions are: Length, 80 ft.; beam, 24 ft.; and sides, 7 ft. high. The deck is crowned 2 in., and a small rail at the bow produces the appearance of "sheer." The hull is divided into eight compartments by a longitudinal bulk-head and three cross bulk-heads. Access is obtained to any part by means of a double hatchway through the deck at the stern, and openings 2 ft. by 2 ft. 6 in. through the cross-bulk-heads. Five concrete "timber heads" are provided for towing and mooring purposes, and are constructed with a view of raising the scow in the event of its ever becoming necessary to do so, heavy reinforcement extending into the bottom of the scow being used.



View of reinforcement in place.

REINFORCED CONCRETE MOTOR LAUNCH IN GERMANY.

The deck, bottom, sides, and bulk-heads are 2½ in. thick, reinforced with ¼-in. steel wire running longitudinally and transversely. In addition to the bulk-heads, the shell is supported by beams and posts, generally 6 in. by 8 in., and reinforced with larger sized round steel rods. In all 12 miles of ¼-in. wire and about 4 tons of larger reinforcement were used.

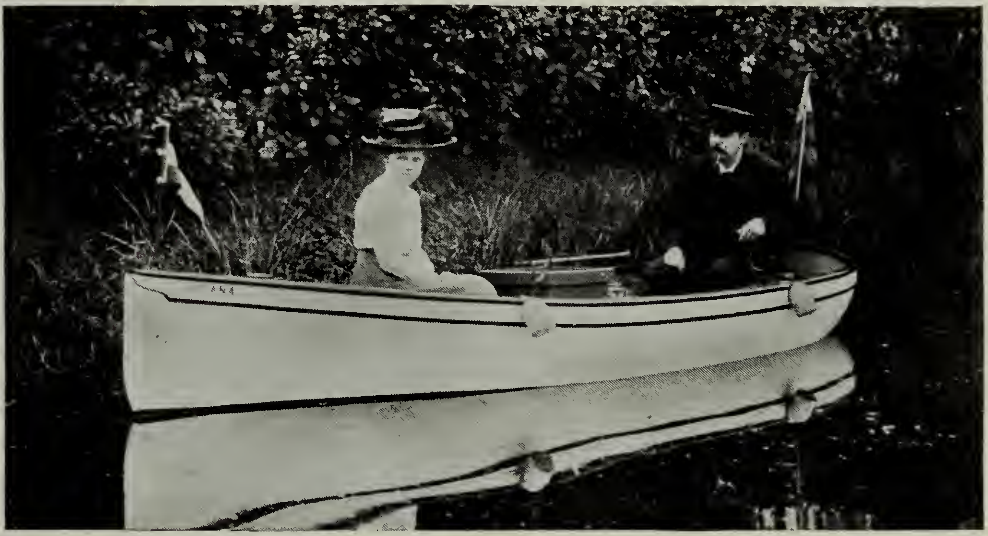
The concrete was placed in the usual manner in reinforced concrete work. A platform was first laid on blocking about 3 ft. above the level of the canal bank, upon which the bottom of the scow was constructed; the bottom beams were next built, the interior forms erected, and the posts, sides, and bulk-heads completed, after which, for convenience, the interior forms were removed and the forms for deck and deck beams erected, and both completed. The scow was then stripped, given a coat of grout, and launched on five ways in the usual manner.

Before launching a careful examination failed to disclose any cracks, and tests with water poured in a few of the interior bays showed no leaks. The draught as reckoned during the design was 2 ft. 8 in., or a displacement of 130 tons ; it actually is a little less, being 2 ft. 6 in. forward and 2 ft. 8 in. aft, leaving plenty of free-board when carrying any load it would be practical to place upon the deck. The scow is, however, designed to carry a working load, which would sink it to the deck.

Since the scow has been in the water no sign of a leak can be found, and the interior is as dry as before launching. Such information as was kept of the cost showed it to be less than for steel construction, and indicates promising commercial possibilities.

Mr. W. H. Sullivan, Assistant Superintending Engineer, made all calculations and designs, and personally looked after the construction of the vessel.

Particulars of this scow are taken from the *Canadian Engineer*, the photographs being placed at our disposal by Mr. J. L. Weller, Superintending Engineer of the Welland Canal, under whose supervision the work was carried out.



View of launch when completed.
Reinforced Concrete Motor Launch in Germany.

REINFORCED CONCRETE MOTOR LAUNCH.

We give on this page an illustration of a motor launch recently constructed in Germany, and on p. 112 there is a view of the launch in course of construction.

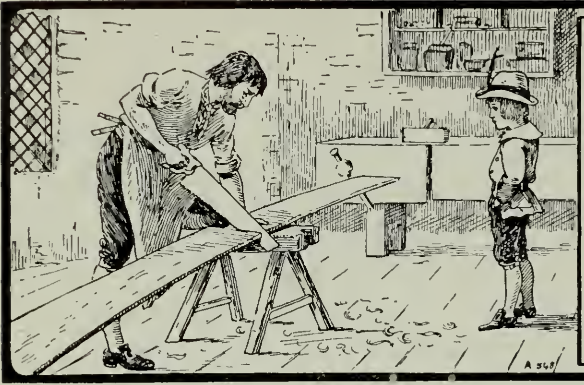
The length over all is 14 ft. 8 in. by 5 ft. 6 in. beam and 2 ft. 3 in. draught. A 3-h.p. motor is fitted, giving a speed of 6 kilom.

The concrete, which is ½ in. thick, is mounted on a network having 1½-in. mesh, supported by fore and aft cross-iron rods. This is covered with an inner and outer skin of fine-meshed wire gauze.

The process of plastering the whole is carried out after the engine bearers and floor frames have been fitted.

The keel consists of a 1-in. iron bar. Five coats of paint were given, each coat taking two days to dry, while the concrete took three weeks. The cost of the hull came to £16 10s.

We are indebted to the courtesy of our contemporary, the *Motor Boat*, for the illustrations of this launch.



"LIGNO"-CONCRETE.

We give particulars below of a new method of reinforcing concrete by means of timber, and also of some tests carried out on the new material, which should be of interest to our readers.—ED.

It has been discovered lately that at one point, where there was a bad sub-soil, the Great Wall of China was built on a kind of concrete raft reinforced with timber, reeds and rushes. Since that time nothing has been done in the direction of using wood to strengthen concrete until Mr. G. O. Case recently invented a method of reinforcing concrete with timber, and from the satisfactory tests which were carried out at the Municipal Technical School, Brighton, it appears to be possible to economically reinforce concrete with timber rods. The results of these tests are given in this article, as well as illustrations of some of the slabs tested.

It is not intended that this new system should enter into competition with reinforced concrete, as wood could not be as suitable as steel for all purposes; but it is probable that "Ligno"-concrete could compete advantageously with ordinary plain wood construction as used in piles, posts, beams, fences, foot-bridges, etc., and in all sea and river works, as owing to decay, attack by marine worms and insects, wood is quite unsuitable for such work. It could also be used advantageously for making walls, floors, etc.

METHOD OF CONSTRUCTION.

In constructing piles, columns, posts, etc., in accordance with Mr. Case's system, three or more vertical rods of wood are joined together at suitable intervals by iron or wooden bands securely fastened to each rod by nails or screws. This forms a rigid framework, which is entirely embedded in concrete. The same method is employed for constructing walls.

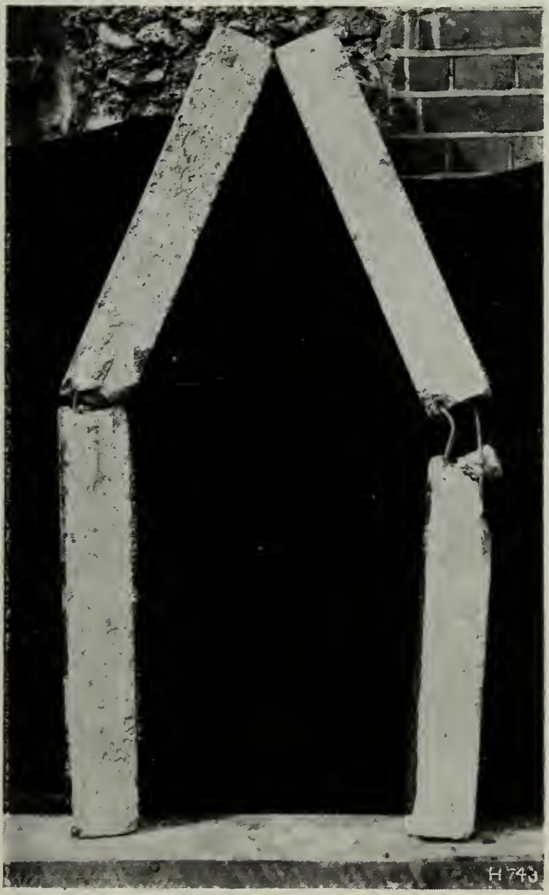
Two methods have been adopted to prevent possibility of the wood taking any moisture from the concrete. The framework can be creosoted, or it can be soaked in water for a short period before casting the concrete round it. Tests have shown that either of these methods will satisfactorily prevent any injurious expansion of the wood during the setting of the concrete. It would appear at first sight that if the framework were first soaked there would be a subsequent loosening of the bond between the wood and the concrete in the process of setting and drying out, but this does not seem to take place, which is accounted for by the fact that while the timber in the framework shrinks slightly, due to the drying out of the small amount of water soaked up, the concrete setting in air also contracts, and the one is counteracted by the other.

"Ligno"-concrete posts have been made with creosoted framework and with soft wood framework previously soaked in water. When broken up after four months' seasoning the adhesion appeared to be perfect in both cases. The soft wood which had been soaked appeared to be quite dry when taken out of the concrete.

In constructing harbour works in America, to combat the ravages of the *teredo*, timber piles are often driven into the sea bed, and sewer pipes or timber tubing is dropped over the piles to the shore level, the space between the piles and sewer pipes being then filled in with concrete. In some cases scour of the sea bed has subsequently taken place, and it has been found that the concrete filling does not drop to the new sea bed but adheres to the piles, being supported by the adhesion between the timber and the concrete.

PRESERVATION OF WOOD INSIDE CONCRETE.

When creosoted frameworks are used and the concrete is made impervious to water, it seems quite obvious that decay of the wood cannot take place. The available evidence also seems to show conclusively that even uncreosoted timbers are effectively preserved when embedded in properly made concrete.



Concrete Slabs Reinforced with Steel Rods.

When the old Convict Prison at Chatham was pulled down a number of common deal levelling stumps, about 2 in. sq., were found embedded in the concrete foundations. The parts of the stumps which were embedded in the concrete were found to be in a perfect state of preservation, while those which had projected in the ground below had rotted completely away.

Jarrah wood has for a number of years been employed in Australia in building operations, and it has been found that it will not decay when built into masonry, although no special precautions are taken.

At Rockhampton, Australia, a wharf was constructed by Mr. T. Parker, civil engineer, over 15 years ago, consisting of a central row of hardwood piles surrounded by concrete. An examination of the work after 18 months proved that it was quite sound, and that the concrete adhered "most tenaciously to the timber."

The preservation of piles used in sea-coast work in America has, according to a writer in *Engineering News* (January 4th, 1906), settled down to the application of a covering of concrete in the manner before mentioned.

TESTS CARRIED OUT ON LIGNO-CONCRETE.

A number of ligno-concrete, plain concrete, and reinforced concrete slabs (or beams) were tested at the Brighton Municipal Technical College in July and September, 1910, in the presence of Prof. C. A. M. Smith, M.Sc., M.I.Mech.E., M.I.E.E.; Dr. Burnie, Principal of the College; Mr. G. M. Butt, timber merchant, Brighton; Mr. G. O. Case, civil engineer, and others.

The slabs were all 4½ in. by 4½ in., and 55 in. long, they were made on works under ordinary working conditions, and seasoned in the open air. The reinforcement in the ligno-concrete slabs (except in No. 9) consisted of four ¾-in. square timber bars, 2¼ in. from centre to centre, and 52 in. long. Iron bands made of ½ in. by ⅛ in. iron were placed over the wood bars 3 in. from either end and 9 in. apart, and were fastened to the timber bars by eight screws, the screws projecting ¼ in. into the concrete. No. 9 slab was reinforced with a timber framework similar to above, except that wood bands made of ⅜ in. wood were used instead of iron bands. The concrete, except in No. 12, was composed of 2 parts granite chips, 2 parts sand, 1 part cement. In No. 12 slab the concrete was made with shingle instead of granite chips.

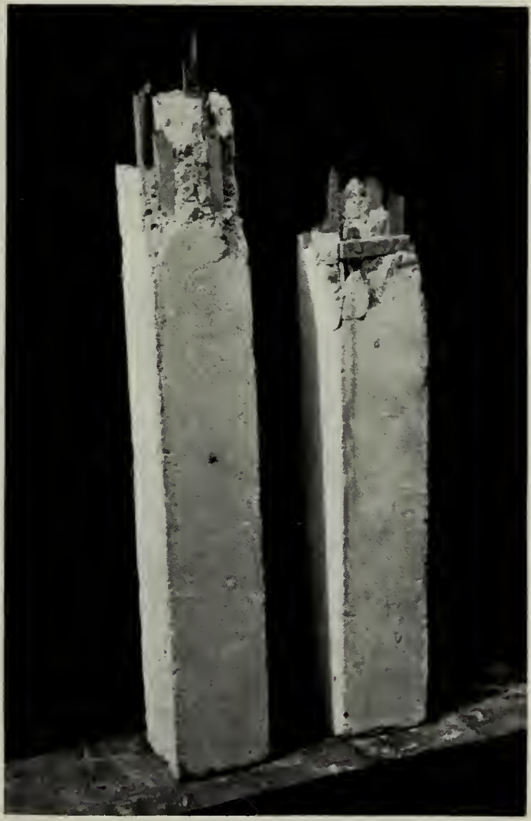
Slabs No. 11 and 12 were reinforced with four ¼ in. steel bars placed in same position as the timber bars in the ligno-concrete slabs. The timber frameworks, except those in No. 5 and 6 slabs were soaked in water before being embedded in the concrete. All the slabs were tested with a central load, span 42 in.

The following table shows results of tests made :

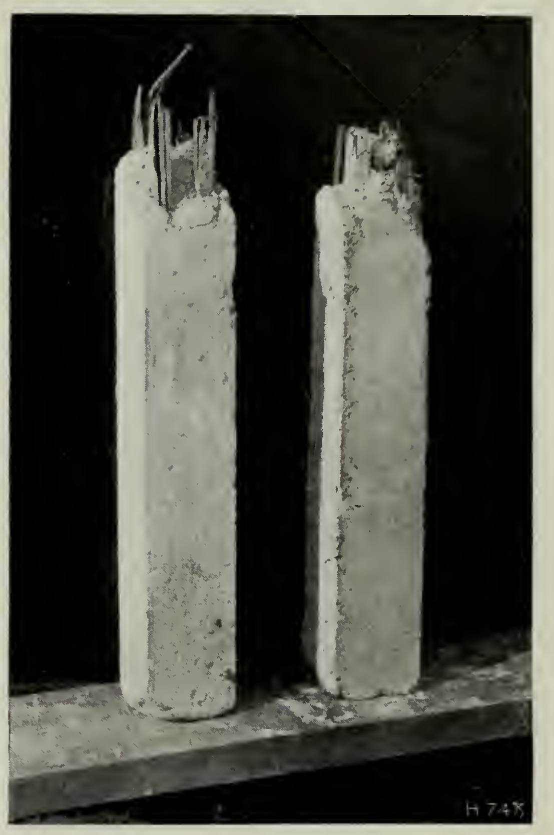
Test No.	Description of Slab.	Age of Slab (Days)	Initial Cracking Load in lbs.	Maximum Load in lbs.	Remarks.
10	Granite concrete reinforced with four ¾-in. jarrah rods, connected by iron bands (3 in. square, ½ in. by ⅛ in. iron)	10	850	3,300	Crack gradually opening, rods broke at maximum load.
9	Granite concrete reinforced with four ¾-in. tallow-wood rods, connected by wood bands (3 in. square, ⅜ in. tallow-wood)	10	1,050	3,150	Four cracks gradually opening, rods broke at maximum load.
5	Granite concrete reinforced with four ¾-in. teak rods, connected by iron bands (3 in. square, ½ in. by ⅛ in. iron)	12	1,400	2,500	Three cracks gradually opening, rods broke at maximum load.
7	Granite concrete reinforced with four ¾-in. spruce rods, connected by iron bands (3 in. square, ½ in. by ⅛ in. iron)	6	Initially cracked in cartage	2,250	Cracks gradually opening, rods broke at maximum load.
3	Granite concrete reinforced with four ¾-in. oak rods, connected by iron bands (3 in. square, ½ in. by ⅛ in. iron)	14	1,400	2,240	Ditto
4	Granite concrete reinforced with four ¾-in. ash rods, connected by iron bands (3 in. square, ½ in. by ⅛ in. iron)	12	1,000	1,800	Ditto
6	Granite concrete reinforced with four ¾-in. mahogany rods, connected by iron bands (3 in. square, ½ in. by ⅛ in. iron)	12	1,200	1,595	Ditto
11	Granite concrete reinforced with four ¼-in. steel rods, connected by wire links ($\frac{1}{16}$ in. diam.)	14	900	1,500	Cracks gradually opening : at maximum load, steel rods bent up, concrete cracked off.
12	Gritty beach concrete reinforced with four ¼-in. steel rods, connected by wire links ($\frac{1}{16}$ in. diam.)	15	500	1,000	Ditto
8	Granite concrete slab not reinforced	10	—	650	—
2	Ditto	12	—	425	—
13	Stringy bark framework only ...	—	—	300	—

The results seem to show that concrete can be efficiently reinforced by wood as well as steel, although, of course, larger timber bars have to be used to get the same resultant strength.

As the results obtained by these tests were so satisfactory, and showed that this new form of construction was worth further investigation, additional and more exhaustive tests are now being carried out at the East London College, the results of which we hope to publish at a later date.



Test No. 9. Tallow-wood Rods.



Test No. 10. Jarrah-wood Rods.

The cost of ligno-concrete is, roughly speaking, estimated by the inventor to be about 38 per cent. cheaper than oak, and 16 per cent. cheaper than reinforced concrete or pitch pine.

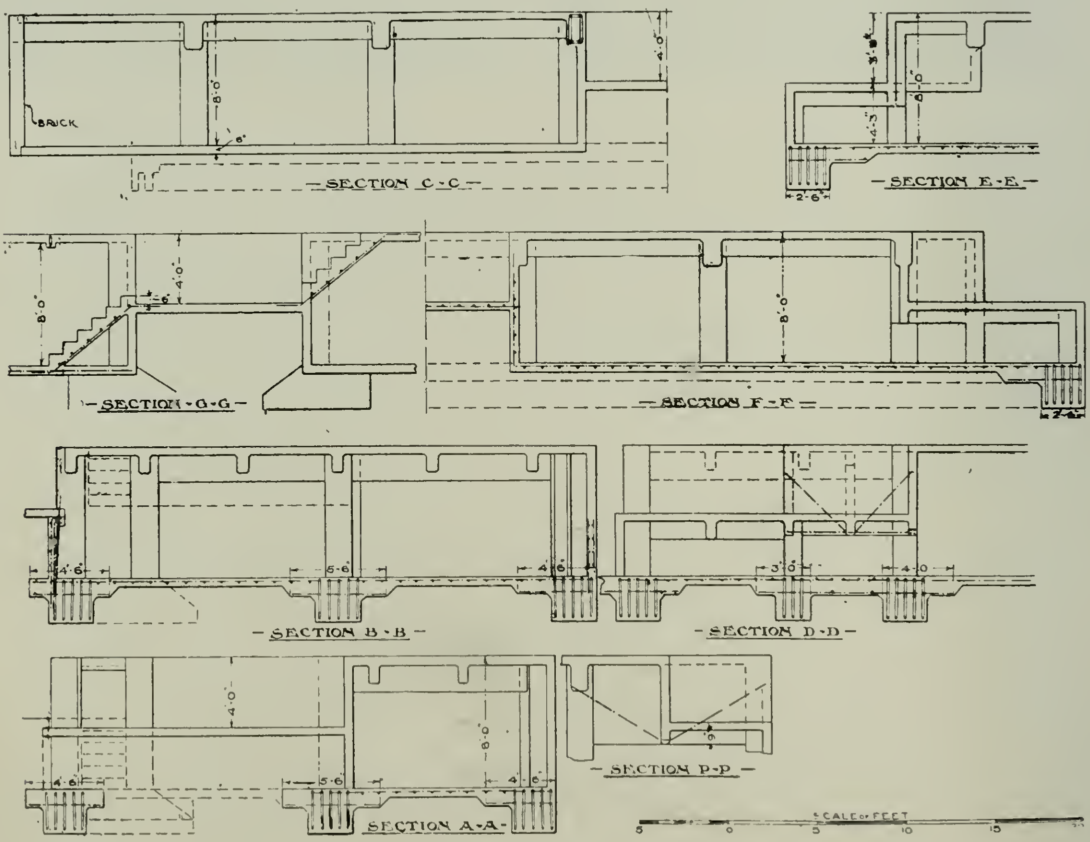
The inventor of this system is Mr. G. O. Case, Civil Engineer, of 47 Victoria Street, S.W., and a patent has been applied for.

EXTENSION OF EAGLE BUILDINGS, DUNDEE.

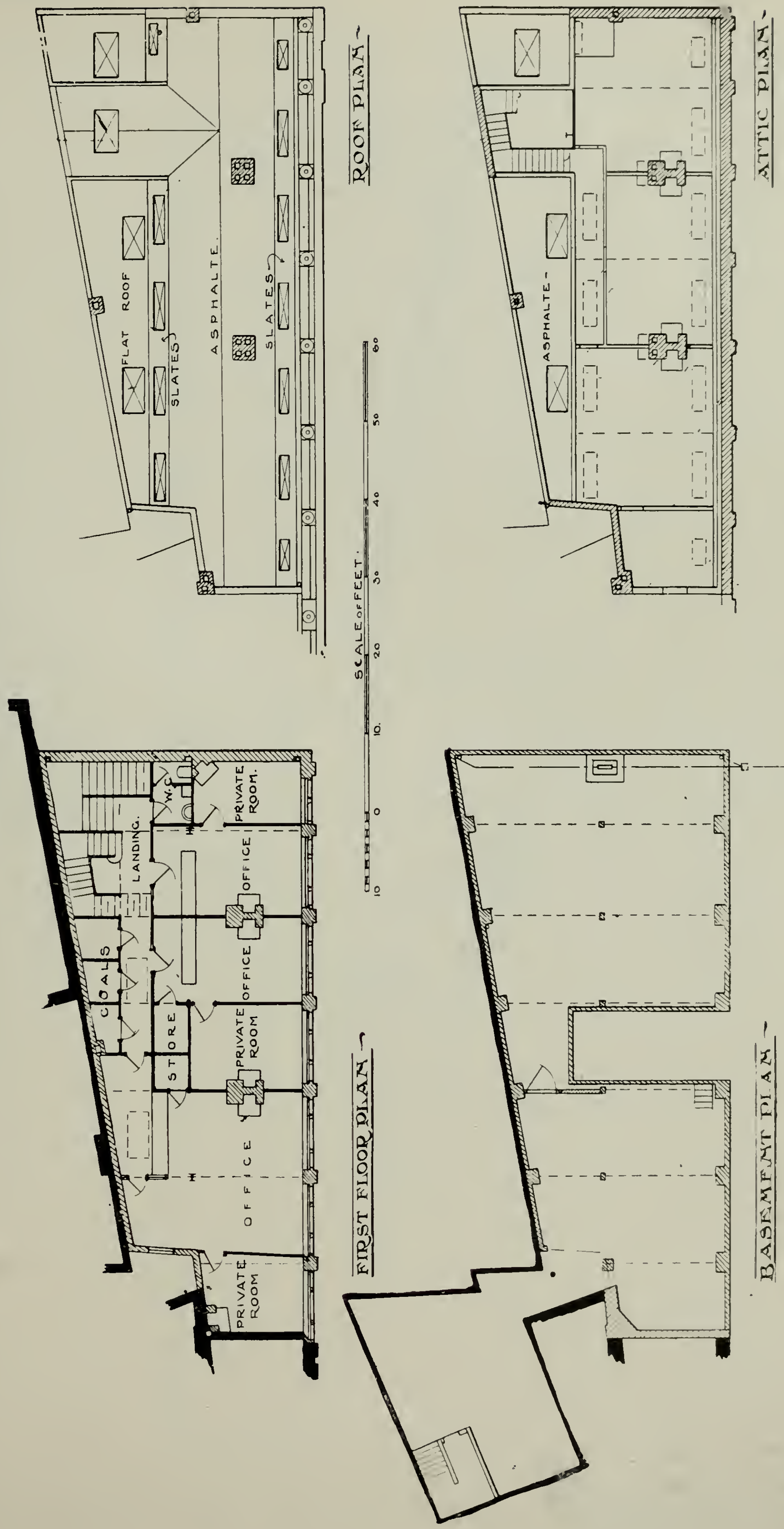
In the extension to the Eagle Buildings, Dundee, described in this article, both reinforced concrete and steel framework construction were employed, and particulars of the work should be of interest.—ED.

The extension of Eagle Buildings, Trades Lane, Dundee, consists of an addition to a building erected about 30 years ago, built of brick and coated with cement. The new façade is a continuation of the old, the construction of the basement consisting of reinforced concrete, while the superstructure is of steel framework with concrete floors.

The difficulty with this extension was the foundation, as the site is on reclaimed or made-up ground, and subject to tidal water, being quite close to the docks.



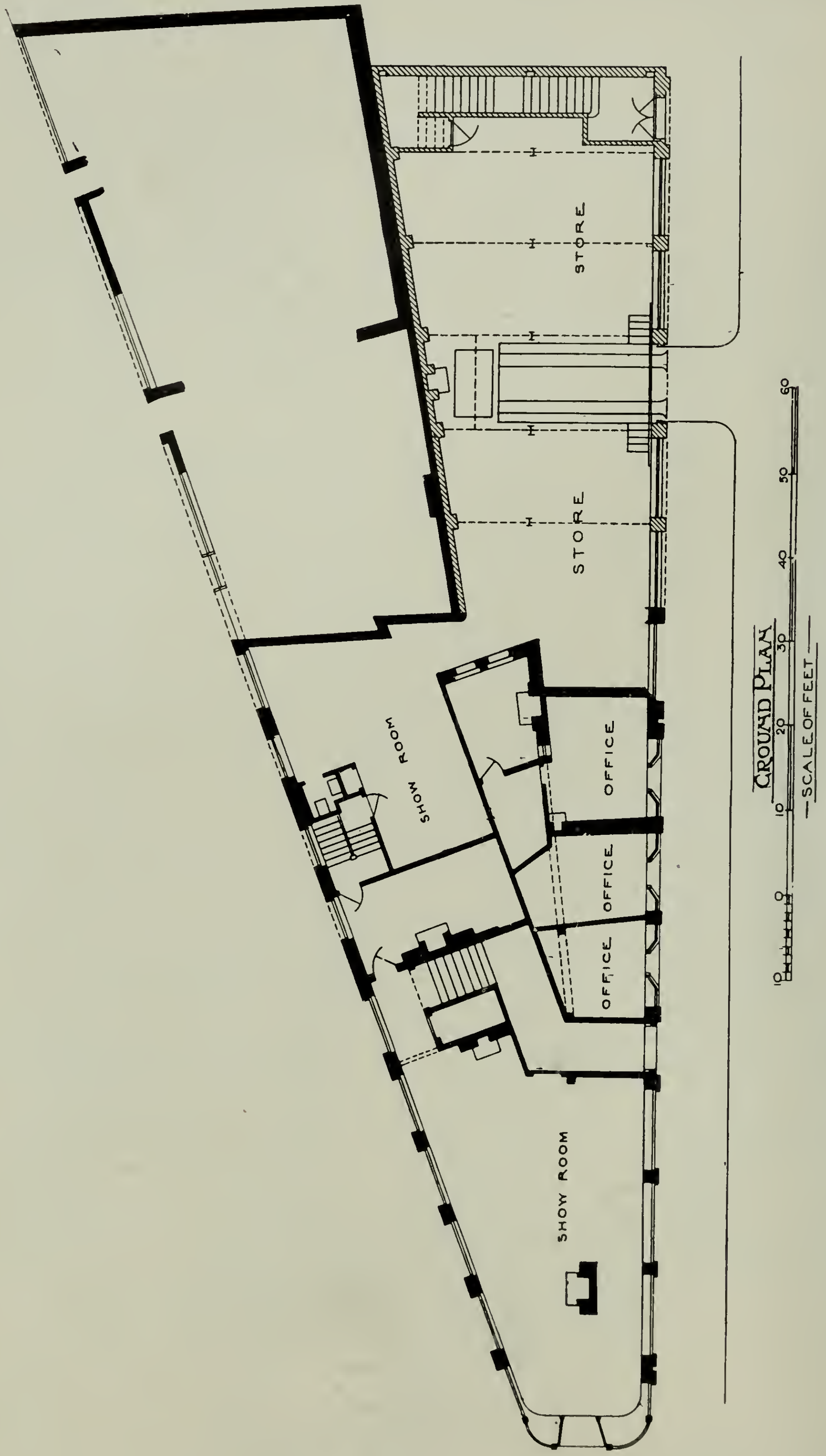
Details of basement walls, etc.
EXTENSION OF EAGLE BUILDINGS, DUNDEE.



Plans.

Extension of Eagle Buildings, Dundee.

The ground floor is constructed to carry a load of 4 cwts. per super foot.



Extension of Eagle Buildings, Dundee.

The basement being used for storing sanitary and cast-iron goods had, therefore, to be kept as dry as possible.

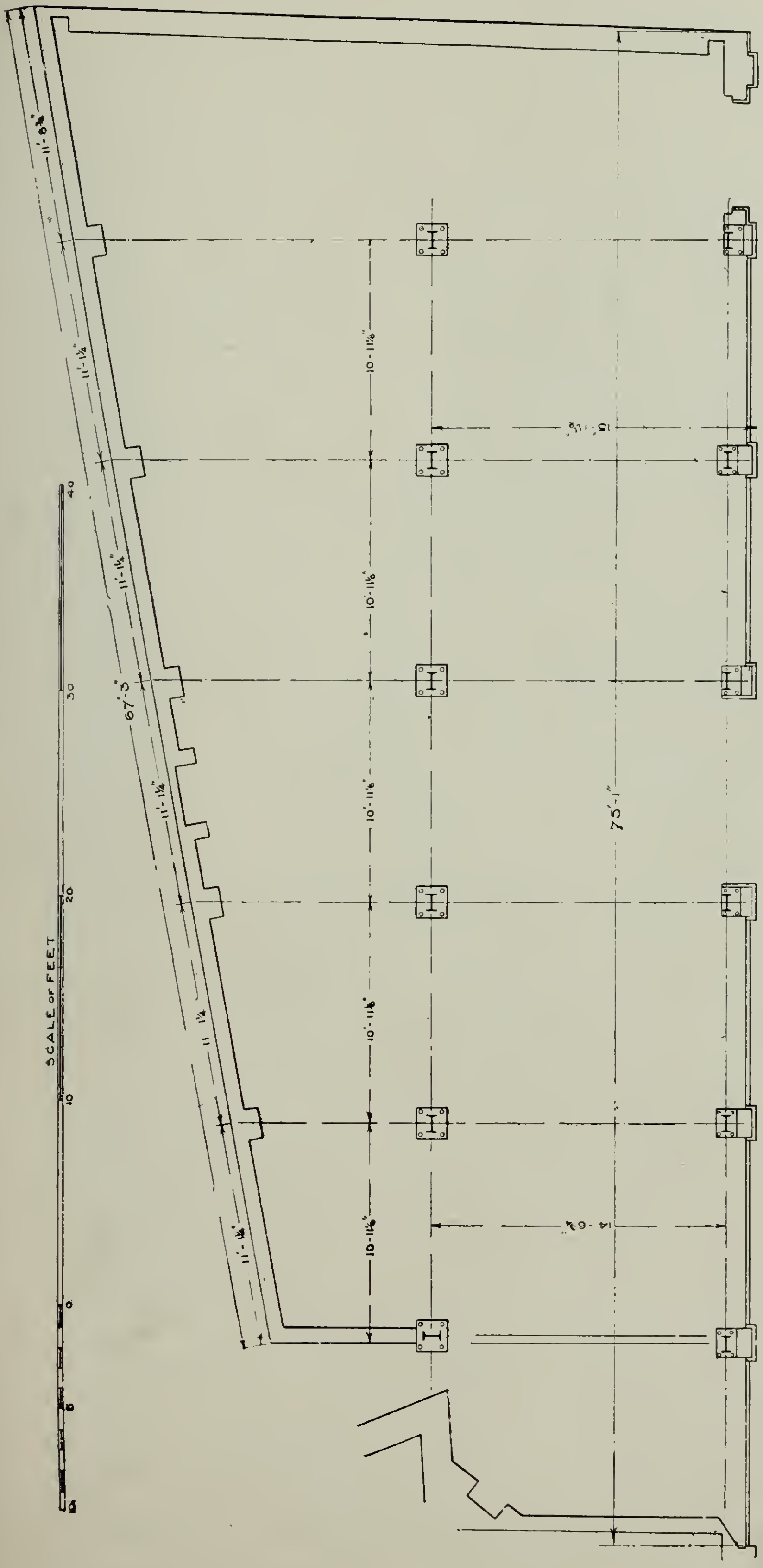
The substructure is practically a reinforced concrete box, of which the ground floor forms the top, the basement floor the bottom, and the basement walls forming the sides.

Owing to the unstable nature of the subsoil, the basement floor, which is 6 in. thick reinforced with $\frac{5}{16}$-in. bars at 12-in. centres both ways, is strengthened by reinforced beams 30 in. by 30 in. under walls and columns along the centre of the building; the upper part of wall beams are spread to 4 ft. 6 in. wide, and beam under column to 5 ft. 6 in. wide.

The walls are 6 in. thick reinforced with $\frac{5}{16}$-in. rods at 12-in. centres.

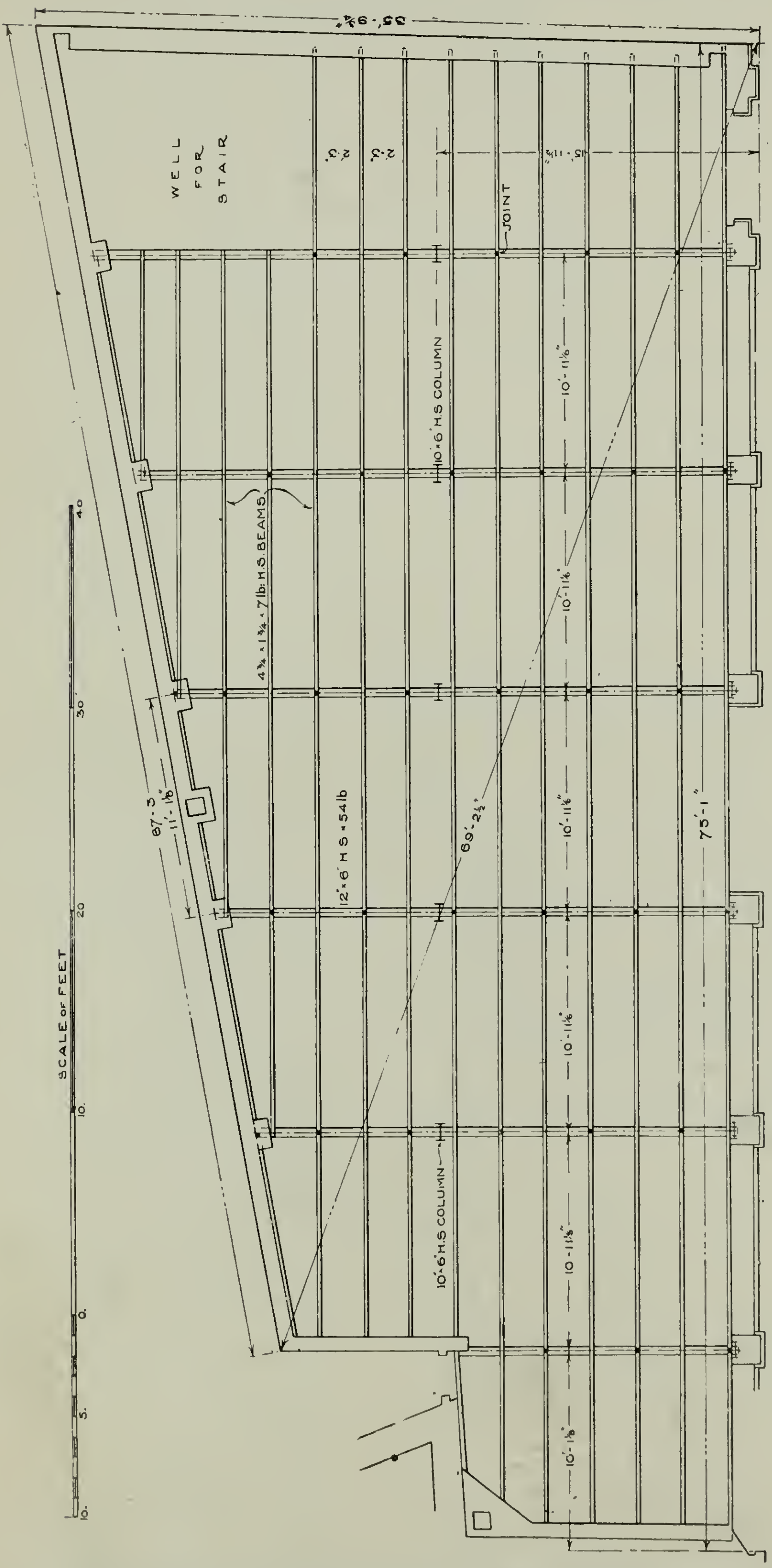
The ground floor is $4\frac{1}{2}$ in. thick reinforced with $\frac{3}{8}$-in. bars at 5-in. centres, and $\frac{5}{16}$-in. cross-bars at 18-in. centres.

The columns at walls and in centre of building which support the ground floor also carry the steelwork of the superstructure. Those columns are 18 in. by 18 in. reinforced with either 1-in. or $\frac{7}{8}$-in. bars with $\frac{3}{16}$-in. links at 9-in. centres. The main beams are 18 in. by



Foundation plan.
Extension of Eagle Buildings, Dundee.

12 in. at 11-ft. centres, and secondary beams 12 in. by 8 in. at 5-ft. 4-in. centres.



Plan of beams for first floor.

EXTENSION OF EAGLE BUILDINGS, DUNDEE.

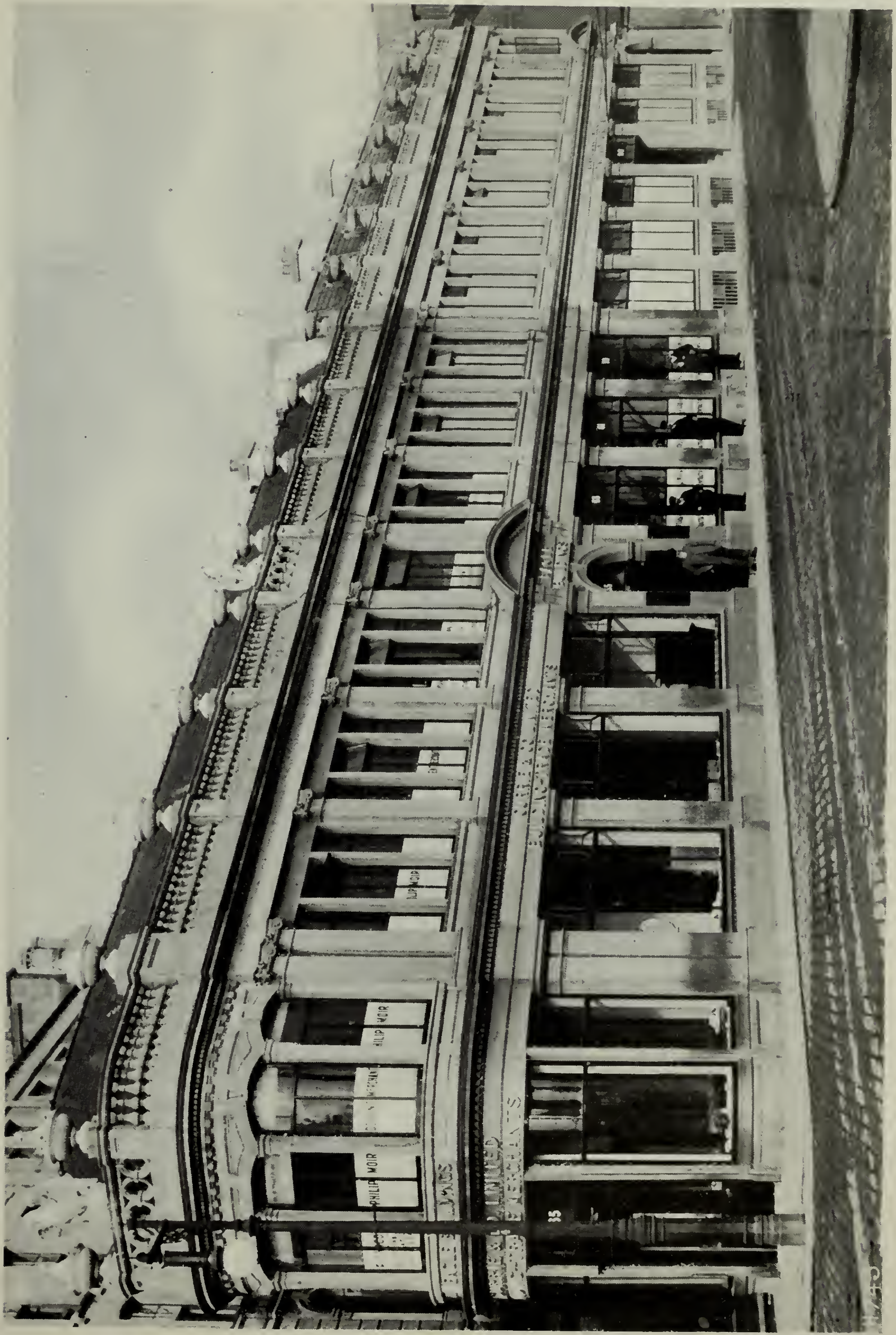
The superstructure is a steel frame building consisting of rolled steel joists, the façade being built of brick and coated with cement, and openings are lintelled by rolled steel joists encased in concrete.

The first and second floors are formed of 4¾-in. by 1¾-in. steel joists at 27-in. centres and 7-in. thick concrete. Those floors are occupied as offices.

The whole of the buildings are faced with cement; the pillars, cornices, balustrading and ornamental work, including the eagle surmounting the front entrance, also being of Portland cement.

The aggregate used throughout consisted of 1-in. whinstone chippings and whinstone dust from Craigie Quarry, Dundee.

The contractors for the reinforced concrete were Messrs. Nicholds & Reynolds, Ltd., of Westminster; and for the steelwork of the superstructure, the Clyde Structural Iron Co., Ltd., Glasgow. The architects were Messrs. H. & F. Thomson, Dundee.



View of finished buildings.
EAGLE BUILDINGS, DUNDEE.

METHOD FOR THE COMPUTATION OF REINFORCED CONCRETE FLAT SLABS.

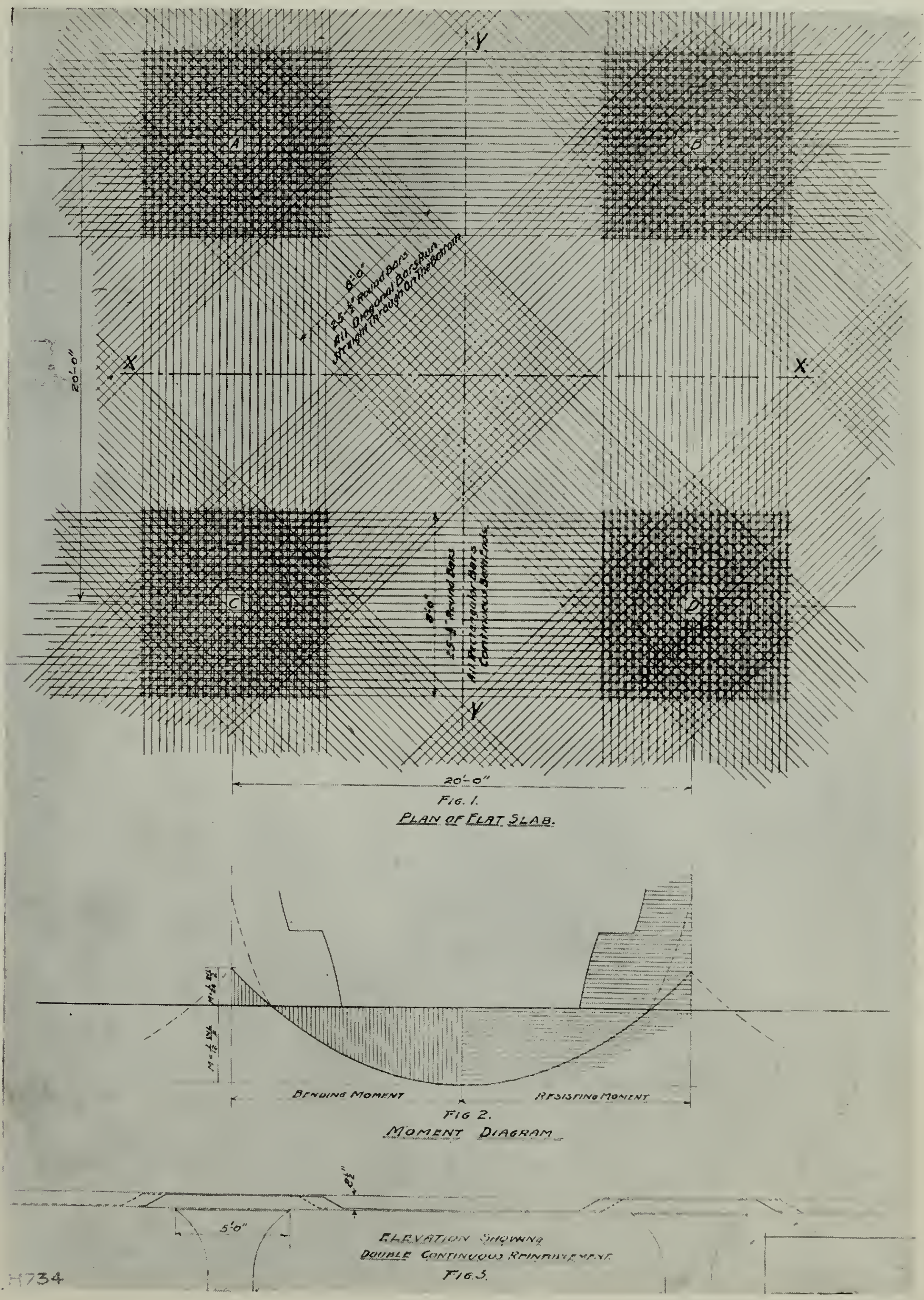
By LOUIS F. BRAYTON, Portland, Ore.

Below will be found a most interesting paper prepared by Mr. Louis F. Brayton, of Portland, Oregon, U.S.A., for a meeting of the National Association of Cement Users of America, which should be read by all interested in the calculation of reinforced concrete. This paper took the form of a discussion on one entitled "A Comparison of Methods of Computing the Strength of Flat Reinforced Concrete Plates," which had been presented by Mr. A. B. MacMillan at a previous meeting of the National Association of Cement Users.—ED.

Without question, one of the most useful, as well as one of the least understood types of construction, is the Reinforced Concrete Flat Slab. This type is extensively designed by C. A. P. Turner, under the trade name of the "Mushroom System," and has been discussed by Angus B. McMillan in a paper read before the Sixth Annual Convention of the National Association of Cement Users, Chicago, 1910, in which a number of solutions for this problem are presented. The fact that his summary indicates a variation of about 400 per cent. between the lowest and highest amounts of steel used under the various methods of computation where the same problem is under consideration, fully indicates that there is at least no accepted method of computation in general use. Without going into the details of the various methods, it may be generally stated that nearly all of them use as a basis the idea that a slab deflects in the form of a warped surface. It might be said that it is assumed that the slab droops around each column in an umbrella form, the curve being reversed as it approaches the centre of the span until it meets the corresponding curve from the next column.

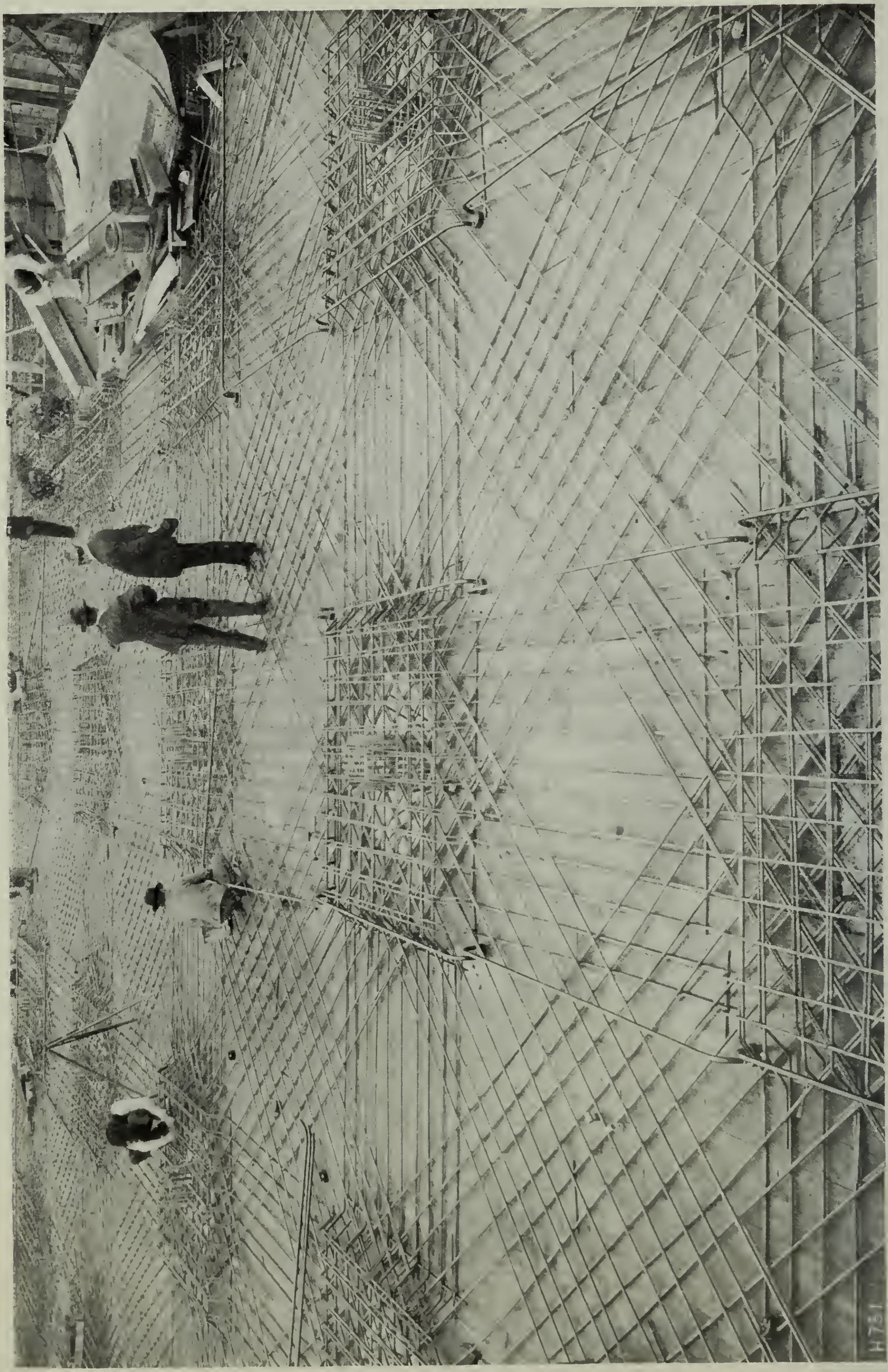
In the writer's mind, where the flat slab is designed on columns equi-distanced apart in each direction, that is, the panels being square, and where the load is absolutely uniform all over the entire floor, there is probably no question about the slab deflecting into the form of a warped surface, as described above. However, when a panel is oblong, and the thickness of the slab uniform, there will *probably* be a greater stiffness in the direction of the shorter span, and the deflection will not necessarily take the form of a warped surface. The greater deflection in the slab *may* take place along a line perpendicular to the centre of the long span. This argument is presented to put the problem in another light. It is not the idea to say that it is impossible for the oblong flat slab to assume the warped surface, but it is intended to say that it *may be possible* that it *may* not under *all* conditions take the form of the warped surface.

Another point of view which must be considered, is that if we grant that the flat slab under a uniform load will assume the form of a warped surface when it deflects, are we at liberty to take this fully into account in making our calculations? Take, for example, a slab supported upon four sides by girders. In this case there can be absolutely no question but that the slab under a load does assume a warped surface, for the deflection under both spans is the same, and, since the girders are considered practically non-deflecting and the centre of the slab does deflect, there can be no other condition but that the slab is warped and dished under the load.



Plan of Flat Reinforced Concrete Floor Slab ; also Moment Diagram and Elevation.

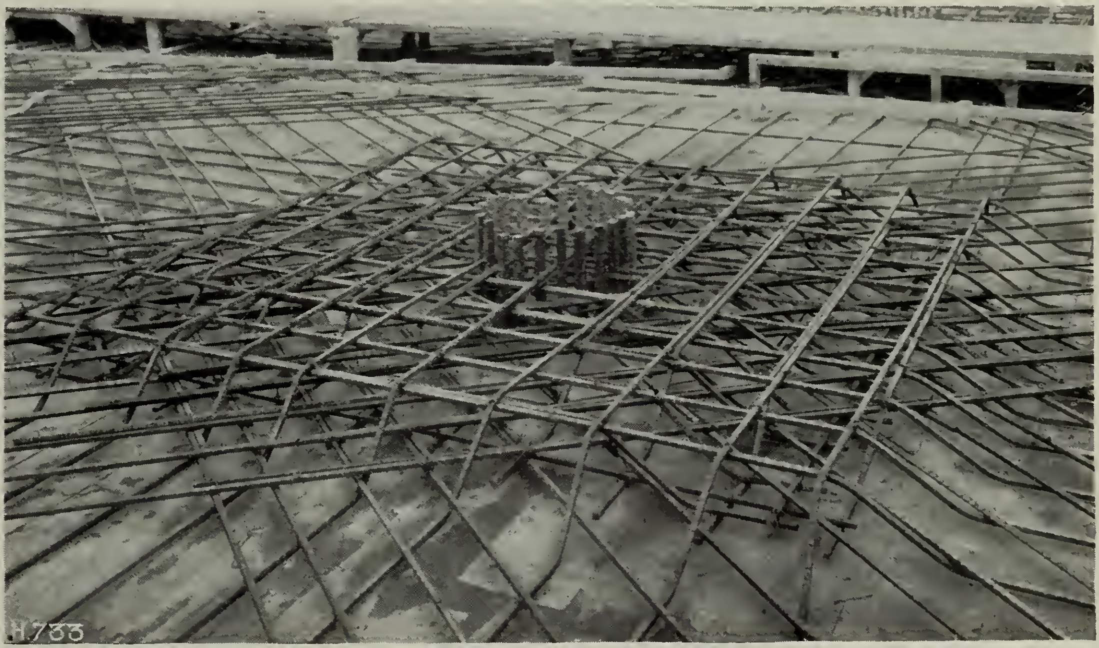
Building departments and engineers throughout the country do not give slabs, supported upon four sides, very much credit for this warping. Probably the most



Basement floor reinforcement in place.
SEATTLE ELECTRIC COMPANY'S BUILDING, U.S.A.

usual concession given by a building department is that the load may be considered carried in the direction of the two spans—that is, where the panel is square, one-half of the load is carried each way—and after determining the amount of steel required under these conditions, the amount actually required may be considered as equal to three-quarters of that figured, the bars being gradually increased in spacing toward the ends of the span. This, the reader must remember, is a concession made under the condition only where there is absolutely no question that the only form that the slab can assume under deflection is that of a warped surface. In a flat slab where there are no beams along the centre lines of the columns, as noted above, it is not certain by any means that the slab under a load will deflect in the form of a warped surface, and under these conditions the attitude of engineers and building departments certainly ought not to be more liberal than where a slab deflects, as it would when supported by girders on four sides.

Another condition which probably in a large number of slabs under test has come into effect, is the fact that the flaring caps in the columns are so perfectly a part of the slab and column at the same time, that a large part of the strength of the slab is due to the fact that it is fixed about the columns, and that through a moment of resistance in the columns the slab is materially strengthened. In other words, an eccentricity is created in the column by means of its continuity with the slab. A proper engineering design would not contemplate this eccentricity in the columns unless the columns were designed to take it, which, in the interest of economy, cannot be done.



Slab bars over column cap.
Goodwin Building.

It seems to the writer that under the conditions discussed, a fair solution of the problem would consider the entire dead plus live load as being carried in the direction of the long span where the length is greater than one and one-half times the breadth; the bending moment, however, being calculated on the most liberal basis consistent with good engineering. When a panel is square, it ought to be fair to go to the extreme limit, and consider that the bending moment at the centre of the span is equal to $\frac{1}{24}$ WL, W being the entire dead plus live load. This is equivalent to considering half the load carried in each direction, but using the more conservative factor $\frac{1}{12}$ instead of $\frac{1}{24}$, thus giving credit for deflection in two directions.

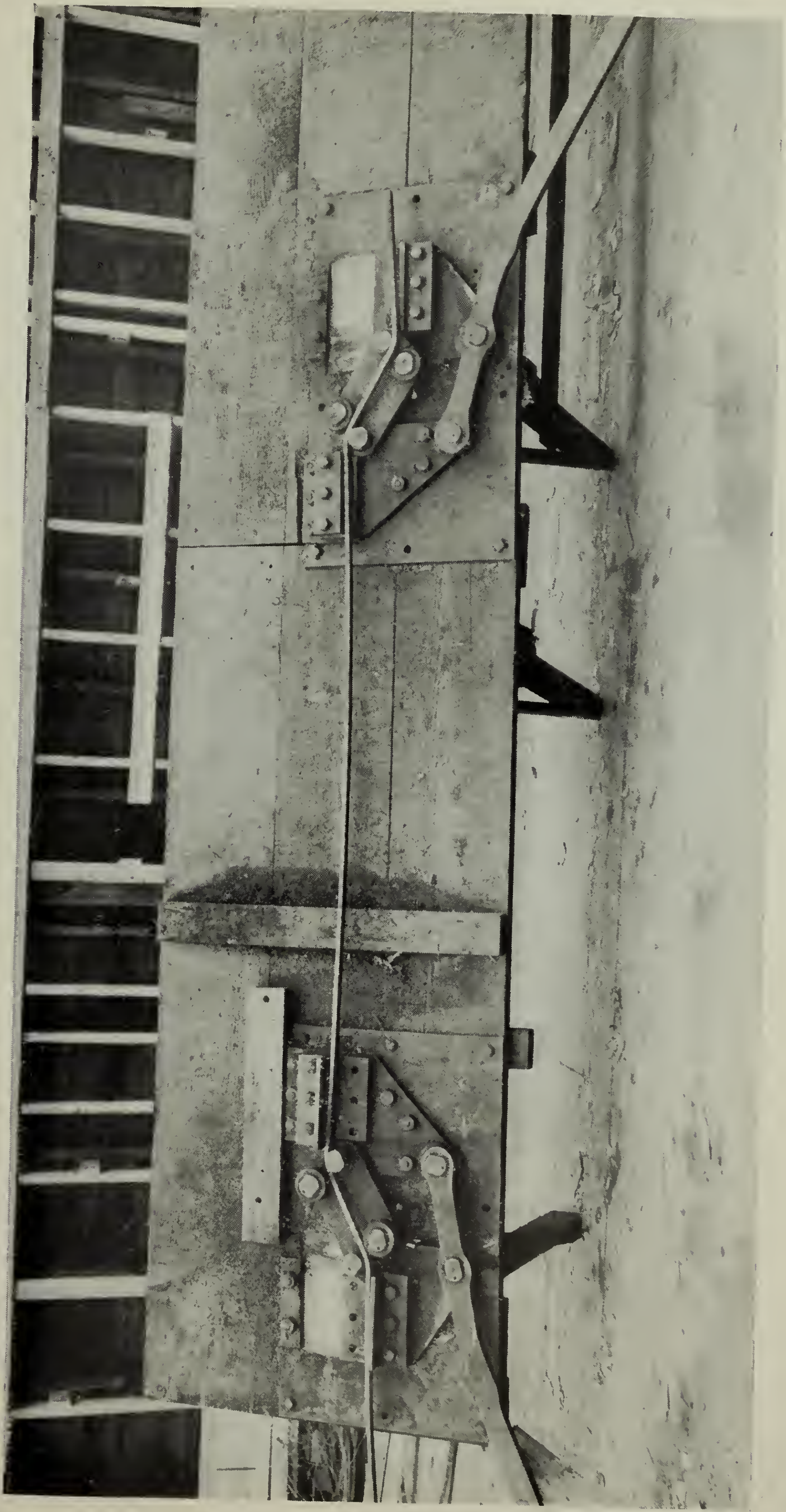
When a panel is oblong to the extent of one and one-half times its width, the whole load should certainly be carried on the long span, using a formula for bending moment giving M equal to not less than $\frac{1}{12}$ WL at the centre, and $\frac{1}{24}$ WL at the supports.

For panels only slightly oblong, it is a question whether the proportion of load carried by the long span can be properly considered as equal to the proportion usually considered in slabs supported on four sides.

The illustrations given herewith represent a flat slab where the columns are spaced 20 ft. on centres each way, and where the design is made for a live load of 200 lbs. per sq. ft. A plan (*Fig.* 1) is given on page 125 showing the arrangement of the bars, their number in each band, and the widths of the bands. A moment diagram (*Fig.* 2) is given taken along the centre line of columns A–B. A section (*Fig.* 3) page 125 is shown also of the slab taken along the same line, indicating the arrangement of reinforcement constituting the band A–B, but not indicating the bars in the diagonal bands. In the moment diagram a parabolic moment diagram indicates the location of the moment when it is considered that one-half of the load is carried in the direction of each span. the bending moment M being considered as equal to $\frac{1}{12}\,\frac{WL}{2}$ at the centre of the span, and $\frac{1}{24}\,\frac{WL}{2}$ at the point of support. This negative moment of $\frac{1}{24}\,\frac{WL}{2}$ at the support, however, is based on a strip of the same width as that considered at the centre of the space, and since the width of the column-cap resisting-negative moment is only about 40 per cent. the width of the panel, the total negative resistance which must be provided per foot of width of cap must be at least two and one-half times this amount.

In order to design a slab and reinforcement to resist these bending moments, a strip 1 ft. in width running from A to B is assumed having a span of 20 ft., and a live plus dead load of 307 lbs. per sq. ft. Using a stress in the steel of 16,000 lbs. per sq. in., and an extreme fibre stress in the concrete of 600 lbs. per sq. in., it will be found that a net depth of 7½ ins. at the centre of span is necessary, that the steel required at the centre of the span must be doubled over the column, and that since the entire strength of the concrete at 600 lbs. per sq. in. has been developed at the centre of the span, the compression resistance must be increased enough to take care of the negative moment of resistance at the point of support. The cross-section through the slab along the line A–B indicates how this steel is bent to the exact form, and how the over-lapping ends, coming from each side of the column, give over the column double the amount of steel that is supplied in the centre of the span. The moment diagram shows on the right the positive moment of resistance at the centre of the span, and negative moment of resistance toward the point of support as it is created by the doubling of the reinforcement at the top of the slab, and the increasing of the compressive resistance of the slab due to the influence of the flaring column cap and the diagonal reinforcement of the slab. It will be seen by the resistance diagram on the right that the shaded area amply covers the moment diagram.

Having determined the amount of steel required per foot of width in the band A–B, the next step is to determine the width of this band. As it is considered that the slab might fail by deflecting along the line Y–Y, it will be seen that concrete will be put into compression, and steel will be put into tension along lines perpendicular to Y–Y, no matter whether the point considered is within the band A–B or in one of the bands A–D or C–B. The fact that the steel through the centre of the panel is placed diagonally, does not necessarily mean that the lines of stress in the concrete must be diagonal, for since the line Y–Y may be along the line of maximum deflection, the lines of stress will be perpendicular to Y–Y. So far as concrete



Reinforcement Bending Machine.

compression stresses are concerned, this is simple ; and so far as the steel is concerned, it is simply necessary to resolve the tensile stress in each bar into its components, parallel and at right angles to Y–Y. The sum of the components of the two bands A–D and C–B perpendicular to Y–Y, must be the tensile resistance required for that portion of the panel not covered by bands A–B and C–D. In a square panel it will be seen that 0.707 of the stress in any bar running diagonally will be equal to its component perpendicular to the line Y–Y. Since we have two diagonal systems crossing this portion of the panel, the total stress perpendicular to the line Y–Y will be equal to 1.414 times the tensile strength of either system ; consequently, if we adjust the bands A–B and C–D to such a width that the strip between which remains must be equal to 1.414 times the width of the band A–B, and place the same amount of steel in all four bands, we have supplied the proper amount of steel to resist bending along the line Y–Y.

In the system here illustrated it is customary to have the bars in the rectangular bands bent and continuous at both ends, while the diagonal bars are straight and run through on the bottom. The rectangular continuous bars are erected first, the diagonal bars being afterward threaded under the negative bars over the column. A study of this system will show that every bar is either carried directly or indirectly over the column cap.

Attention is called to the illustration showing the reinforcement used in which the shear is largely taken care of in the steel.

With the arrangement given, it will be found that the double-continuous rectangular reinforcement in a square panel will almost exactly equal in length the diagonal distance between column centres, consequently, whether the diagonal steel be carried through the column continuously, or whether it be spliced with broken joints, the amount of steel required for the entire panel will be equal to four times that required for one band having a length equal to the diagonal distance between centres of columns.

Following is the solution of the problem already stated, considering the half-load carried in each direction and the bending moment at the centre of the span equal to $\frac{1}{12}\frac{WL}{2}$:

Panel, 20 ft. × 20 ft.
Live load = 200 lbs. per sq. ft.
Dead load = 107 lbs. per sq. ft.
Stress in steel = 16,000 lbs. per sq. in.
Stress in concrete = 600 lbs. per sq. in.
M at centre $= \frac{1}{12}\,\frac{WL^2}{2} = \frac{307 \times 20^2}{12 \times 2} = 5{,}110$ ft.—lbs.
Net depth of slab $= 7\frac{1}{2}$ in.
Total thickness, $8\frac{1}{2}$ in.
Area of metal per ft. width = 0.6 sq. in.
Area of metal for width of $8\frac{1}{3}$ ft. $= 8\frac{1}{3} \times 0.6 = 5$ sq. in.
Bars required per band = 25—$\frac{1}{2}$ in. round. Spacing, 4 in. O.C.
Total steel in panel, 100—$\frac{1}{2}$ in. ; round, 28 ft. 6 in. @ .667 = 1,900 lbs. per sq. in.
Weight per sq. ft. = 4.75 lbs.

It may be noted that when a square slab is designed on a basis as set forth above, L being the distance from centre to centre of column, and W being the total dead plus live load per square foot, the weight of steel required in the slab per square foot may be closely determined by the following formula :

$0.135\,L\sqrt{W}$ = the weight of steel per sq. ft.

Applying this to the above problem we have

$0.135 \times 20 \times \sqrt{307} = 4.73$ lbs. per sq. ft.

It is interesting to compare the above design with various designs given by McMillan. For purposes of comparison, McMillan's table with the above result added is herein reproduced .

FIBRE STRESS

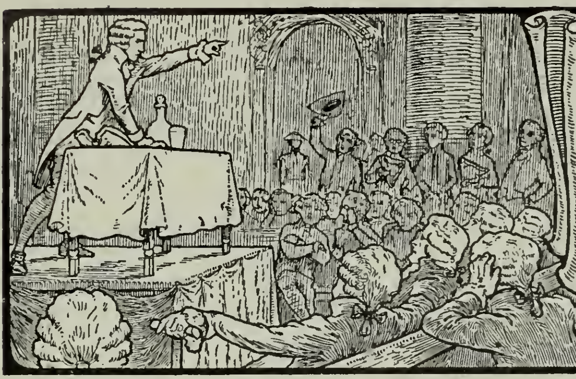
	Method.	Thickness of Slab.	Per Sq In. in Steel.	Lbs. Steel in Panel.
1	Cantilever	8 in.	16,000	2,189
2	Turneaure and Maurer	12 in.	16,000	1,931
3	Grashof...	8 in.	16,000	784
4	Mensch...	8 in.	16,000	2,120
5	Turner (a)	8 in.	16,000	549
	(b)	8 in.	13,000	718
6	McMillan	8 in.	16,000	1,084
7	Brayton	8½ in.	16,000	1,900

The writer believes that the system shown, particularly in its detail, has advantages which are apparent to most engineers, in that the shear or diagonal tension in the slab is very materially assisted by the arrangement of the reinforcement. and the bars, because of being bent mechanically, are positively located so that they take care of the negative bending moment.

The bending of these bars economically done by means of a right and left double-bar bender (*illustration of which is shown on page* 129), at a very low cost, puts four bends in a bar at once and ensures the bending of the bar to exact detail.

Springing the bars into place, or allowing them to sag under their own weight leaves a great deal to the contractor, and causes a lack of confidence in the engineer that the reinforcement will be placed exactly as he intended it. Circular cracks running around the top of a column in a slab are utterly impossible when the steel is as exactly placed as it is shown in these illustrations.

The fact also that two systems of steel occur in the top surface means that the effectual depth is not materially decreased as it is where it is necessary to carry all four systems to the top surface.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

THE NEW GENERAL POST OFFICE.

Paper by SIR HENRY TANNER, Kt., I.S.O., F.R.I.B.A.

At the Ordinary General Meeting of the Royal Institute of British Architects, held on January 2nd, Mr. Leonard Stokes, president, in the chair, Sir H. Tanner, I.S.O., read a paper on "The New General Post Office," of which we give an abstract.

We have dealt with this building on several occasions, and would refer our readers in particular to our issues of January and July, 1909, for details of this important work.

Owing to the fact that reinforced concrete works had been gradually coming into notice, I was induced to inspect several buildings of that form of construction, with the result that I came to the conclusion that the system was excellently adapted for the purpose of this building, and would economise both space and money, having in view the fact that Government buildings are exempted from the operation of the London Building Acts and that therefore full advantage could be taken of the new methods. Upon going into the matter of cost as carefully as possible, I found that if built in the ordinary way with steel construction, the approximate cost, exclusive of fittings, etc., would be £355,000, but if in reinforced concrete £295,000 would probably suffice. The latter figure has proved to be correct, so that there has been an approximate saving of £60,000, and apart from this, considerable space has been gained due to the great reduction in wall thicknesses. The cost per ft. cub. of the reinforced concrete structure was about 2¼d. The sum of £295,000 is exclusive of engineering work, such as heating, lighting, lifts, telephones, conveyors, etc.

In February, 1906, the Commissioners of Works agreed to my proposal to adopt the Hennebique system, and to the employment of Mr. L. G. Mouchel to act as consulting engineer to collaborate with me in the preparation of the first contract, which consisted of the excavations, reinforced concrete work, and so much general work as was necessary to render the building watertight, but with the exception of the Portland stone fronts. Towards the end of 1906 tenders were received, and in March, 1907, a commencement was made by Messrs. Holloway Bros., the foundation stone having been previously laid by King Edward VII.

In arranging preliminaries, I stipulated that the columns were to be as few and as small as possible, in order to give the largest practicable unobstructed areas, that the beams were to be of the minimum depth, that the eastern platform was to be unobstructed by columns, that there must be a bridge connecting the two buildings at the second floor level, and that two subways were to be constructed under King Edward Street, connecting the new building with those existing. I arranged the superloads at 1 cwt. for the ground floor, and ¾ cwt. for the remaining floors, 65 lb. for the roof, and the factor of safety at 4. These superloads were arrived at after experiment. The north road was to be constructed to support a lorry with boiler weighing about 20 tons in all, and the remaining roads to support motor vans. The superload in the latter case was taken at 2 cwt. per ft. superficial.

Arrangement of Buildings.—The building has two stories below the ground, and these extend the whole length, including therefore the space under the eastern loading yard. The general constructional arrangement of the sorting office or main block is that the principal beams run from north to south, and the subsidiary or floor beams from east to west—that is, the long way of the sorting office. The sorting office has six storeys, and the public office seven storeys. The retaining walls vary from 7 in. to 8 in. thick, strengthened by beams and counterforts, and are, in fact, floors placed on end. They are maintained in the vertical position by the arched beams or struts which are continuations of the main floor beams. The reinforcement in the wall slabs consists of $\frac{7}{16}$-in. diameter horizontal rods spaced at from 4-in. to 10-in. centres on the inside of the wall, and $\frac{5}{16}$-in. diameter rods on the outside spaced at from 8-in. to 24-in. centres. There are also vertical rods of $\frac{5}{16}$-in. diameter spaced at 8-in. centres, and stirrups are used. The vertical counterforts, 14 in. by 7 in., arranged about 5 ft. 6 in. apart, are supported by horizontal beams and are designed in a similar manner to the ordinary floor beams. The former have two bent and two straight bars of 1 in. diameter, and the horizontal beams are similarly reinforced, but with bars of varying diameters.

Columns.—The columns are square, and all are sheathed with steel to a height of 4 ft. to take the impact of trucks, etc. They stand on reinforced concrete slabs about 13 ft. 6 in. square, which are in nearly all cases on the gravel. At the north-west angle, however, clay was found at a higher level, the gravel disappearing. The slabs are reinforced with bars $\frac{7}{8}$-in. diameter placed at 8-in. centres and crossing one another, and are further reinforced with a mesh of smaller diameter bars at various levels and stirrups.

Beams.—The arched main beams are 2 ft. 6 in. in depth at the centres and 5 ft. 3 in. at the haunches, the thickness being 10 in. The depths include the floor slab. The reinforcement for these beams when of 35 ft. span consists of two $1\frac{5}{8}$-in. diameter bars at the top and four $1\frac{3}{4}$-in. or 2-in. bars at the bottom. Two of these follow the curve, and when they reach the haunches pass horizontally through the column and then follow the curve of the adjoining beam, passing 2 ft. into it ; the other two bars are horizontal for a third of the span, then bend up at a slope till within 3 in. of the top, and are carried through the column and 2 ft. into the next beam as before. The two top bars also pass into the adjoining beam 2 ft. There are numerous stirrups $1\frac{1}{2}$ in. by $\frac{1}{8}$ in., and a series of horizontal $\frac{9}{16}$-in. bars passing through the columns and well into the haunches of beams, and also similar bars placed radially to the soffit. For larger spans and the heavier superloads the reinforcement is varied accordingly, and the beams in ground floor are 3 in. deeper in the centre and 2 in. thicker, the maximum being the centre 45 ft. spans.

The secondary or floor beams are 8 in. wide and $19\frac{1}{2}$ in. deep, including the floor slab, and are spaced at about 5 ft. 10 in. centres. They are reinforced with two straight and two bent bars of various diameters with stirrups of $1\frac{1}{4}$-in. by $\frac{1}{8}$-in. hoop steel spaced according to the shear stresses.

Chimney.—The chimney is of reinforced concrete, and although within the area of the main building, is quite independent to allow of expansion and contraction. The internal dimensions are 4 ft. by 3 ft. 6 in., and the height from the boiler house floor is 130 ft. The thickness of the walls varies from 8 in. to 6 in., and the shaft is lined for 50 ft. in height with $4\frac{1}{2}$-in. firebrick, divided into three sections supported independently of each other. Between the concrete wall and the lining there is a $2\frac{1}{2}$-in. air space.

The bridge connecting the two buildings has a span of 50 ft., and is 6 ft. 6 in. wide and 9 ft. 6 in. high. The lower part of the side walls is 5 in. thick, reinforced to form the girders carrying the whole structure, and the upper part 4 in.

The ventilating fan chambers and the ducts thereto, also the lantern lights, have been constructed of reinforced concrete.

The staircases are of reinforced concrete throughout brought up with the other work. Each flight constitutes a slab, the reinforcement consisting of nine $\frac{5}{8}$-in.

diameter bars, four of which are curved. The bars are continued through the landings which have stiffening beams. The longitudinal bars are crossed at 12-in. centres by $\frac{3}{8}$-in. diameter bars, and there are the usual stirrups.

The arrangement of the front building was primarily governed by the requirements of the ground floor, which consists of a large Public Office 152 ft. by 57 ft. with entrance lobbies and a staircase at each end, together with other offices. The supports in the Public Office are placed nearer the walls, leaving a wide centre or nave 26 ft. 10 in. in width, the aisles being 12 ft. 6 in. These supports do not coincide with those of the floors over, the requirements there being rooms to the outside with a central corridor of ordinary width, the columns being on either side of it. Consequently, a deep and strong girder was necessitated to support the upper floor and to transfer the load to the pillars below. These girders run east and west and are 5 ft. deep and 20 in. thick. The reinforcement consists of ten bars top and bottom of $2\frac{1}{4}$ in. diameter placed in pairs ; attached to these are 275 shear stirrups $1\frac{3}{4}$ in. by $\frac{1}{8}$ in. and 255 $1\frac{1}{2}$ in. by $\frac{1}{8}$ in. Each of these girders weighs 38 tons. Those from north to south are merely thin slabs, designed to carry the floor slabs, but otherwise to form architectural beams.

The upper floors were constructed similarly to those of main block, but steel bars and Expanded Metal were used below the beams to give flat ceilings.

Externally the concrete walls were covered with a thin rendering of cement, in the proportion of 1 cement to 2 of sand. It would have been better with a larger proportion of sand.

Reinforcement.—The reinforcement throughout is of round steel rods varying in size up to $2\frac{1}{4}$ in. diameter. The ends are split. All were rolled to the lengths required, no welding was permitted, and the bending was done cold. The stirrups are of hoop steel. The steel is mild, and was required not to fracture with a less tensile stress than 28 tons or more than 32 tons per square inch, with contraction of area at plane of fracture not less than 40 per cent. and with an ultimate extension of 20 per cent. in 8 in.

Cement.—The cement used had to be superior to the usual British standard quality. It had to pass through sieves of 14,400 meshes per sq. in., leaving only 10 per cent. residue ; while briquettes were to break with not less than 500 lb. per sq. in. after 7 days, 600 lb. after 14 days, and 650 lb. after 28 days ; and when made with 1 to 3 of sand, 130 lb. for 7 days and 200 lb. for 28 days. The average results of the test were considerably higher than the specification demanded, being 587 lb. and 702 lb. for neat cement, and 196 lb. and 276 lb. with sand at 7 and 28 days respectively. There were also tests by boiling.

Thames ballast was used throughout, crushed to pass through a $\frac{3}{4}$-in. mesh, but to be retained on an $\frac{1}{8}$-in. mesh, and a good sharp sand to pass $\frac{1}{8}$-in. mesh. The concrete was mixed in the proportion of 27 cu. ft. of crushed ballast and $13\frac{1}{2}$ cu. ft. of sand to 7 cwt. of cement in work below ground, and 6 cwt. above.

Tests.—Portions of the floor were tested with once and a half to twice the superload when the deflection was not to exceed $\frac{1}{600}$th of the span. The superload was allowed to remain for 12 hours, and after 24 hours there was to be no appreciable set. The effective depths of the secondary or floor beams vary from $\frac{1}{25}$th to $\frac{1}{27}$th of the spans, and the maximum deflection under a test load 50 per cent. in excess of the calculated load in no case exceeded $\frac{1}{1000}$th part of the span. The tests were therefore satisfactory, and in no case was there any permanent set. These tests do not, of course, give any results on columns.

A number of 4-in. cubes were made from the concrete as used with the 7 cwt. proportion of cement. Half were of a fairly dry mixture and half wet. Those of the dryer mixture crushed with 1,800 lb. per sq. in. at 2 months, and at 5,600 lb. at 3 years ; while the blocks of wetter mixture crushed with 2,000 lb. at 2 months and at 5,000 lb. at 3 years. It will be seen, therefore, that while weaker to start with, the dryer mixture is the stronger in the long run, practically trebling in strength. These results also show how very much stronger such buildings become by lapse of time, and the judicious provision of a small amount of additional steel is all that is needed to carry additional storeys. As instances in this case, it may be mentioned that additional 1,300-gallon tanks and a rifle range have been installed on the roof, a conveyor on the first floor, etc., without strengthening the structure.

The work has proved reasonably watertight, nothing whatever has passed through the retaining walls, which average 7½ in. thick. There is no asphalte lining, but ordinary cement concrete, 8 to 1, several inches thick was used for filling up the space occupied by the false work at the back of the walls.

Experiments were made with various plastering materials for internal work, and as a result a rendering of Portland cement and sand was used. This so far has proved quite satisfactory.

Co-operation of Engineer and Architect.—Having had experience of several methods of procedure in regard to reinforced concrete work, I can come to no other conclusion than that the method pursued in this case is by far the best. It is of the greatest possible advantage that the architect and the engineer should be able to work together, and this cannot be done when designs and tenders are called for. Besides, it is obvious that with such procedure, if the engineer and his contractors are to hope for any success in competition for work, the steel and concrete must be cut down to the minimum, thus increasing the chances of failure. Much time is lost in the necessary examination and comparison of the designs submitted, and this, with vacant sites, means the loss of more or less money. Such a course is not taken with ordinary steel construction, and it is not usual to ask architects for designs and tenders which would practically amount to the same thing. Moreover, under such a system it is impossible to obtain a satisfactory schedule from which variations can be properly valued.

The time must come when reinforced concrete will be incorporated in the ordinary Bills of Quantities and dealt with in the same way as any other part of the construction, and there are now any number of contractors quite able and willing to undertake and to carry out such works in a satisfactory manner.

With regard to materials, cement can now be regularly obtained to take a stress of 20 per cent. greater than the British standard. Such cement has been used throughout this building and in the test blocks.

The construction of the false work should be of a substantial character so that no movement takes place under ramming, otherwise concrete partially set may be disturbed.

Supervision is of the first importance, and this is necessary during the whole time that concrete is being mixed and deposited, and before the latter is done it is absolutely necessary to see that wood shavings, sawdust, etc., are removed from the false work, and hosing is very useful for this purpose. The positions of the steel work must be observed, as any loose parts may get out of position. Column links are particularly open to this, and such loose parts should be tied together with binding wire. To ensure so far as possible the accurate carrying out of the work in this case three Clerks of Works were employed during the greater part of the time.

DISCUSSION.

Sir M. Nathan, G.C.M.G., proposed a vote of thanks to the lecturer, who, he said, had for the last 12 years prepared the designs for every post office building of importance, and whose leading characteristic in his relations with the Post Office Department during that time has been his willingness to meet their requirements. He has always realised that a building should be designed for the work for which it is intended, and not the work adjusted so as to fit the building. The result is that he is a first-rate planner, which is evidenced in all of the public buildings he has designed, but more particularly in the building just completed for the Post Office. The great feature in its design is the boldness with which Sir Henry Tanner has applied a comparatively new system of construction to a bigger structure than any to which it had been previously applied in this country. The details of construction given in the paper recalled to his (Sir M. Nathan's) mind an experience of many years ago, when he was assistant engineer in the Military Works Department in India, and was called on to design a heavy gun battery on very treacherous foundations. He arranged for the heavy magazines to stand on a raft of concrete, and as it was essential that there should be no cracking or settlement of the foundations, he embedded in the concrete raft a large number of contractor's rails, which he placed at fairly close intervals in a double layer crossing each other at right angles. It was a far cry from this rudimentary reinforced concrete of 22 years ago to the elaborate and carefully planned arrangement of rods, bars, and stirrups, described by Sir Henry Tanner.

Mr. H. D. Searles Wood, in seconding the vote of thanks, remarked that he was specially interested in the treatment given to the outside of the concrete, which, he understood Sir H. Tanner to say, was done when the concrete was green, but he was under the impression that the external rendering had been done after the concrete had been up about two years.

Professor Beresford Pite considered that Sir Henry Tanner had quite justified the confidence in his leadership and ability felt by the profession with regard to works undertaken by H.M. Office of Works. While they were amused at the liberties Sir Henry Tanner was able to take with the Building Act, they never felt any doubt as to his ultimate success. To have had the opportunity of conducting such an experiment and bringing it to success was indeed the crowning work of a great professional career, and this building will be looked upon by architects of another age and generation as a starting-point in construction. He would like to be assured on one technical point, would not the possibilities of the expansion of a homogeneous building be somewhat serious ? This was a matter of great importance if the advisability of employing reinforced concrete be considered in a hotter climate than our own. The whole question of the expansion of this reinforced concrete building, and the extent of the expansion, also the way it will have to be adjusted and provided for, is a subject on which light should be given.

Sir Aston Webb congratulated Sir Henry Tanner on the building which was a perfect revelation indicating a changing of the ways. If architects are to carry out what Sir Henry Tanner has carried out, they must revolutionise all their ideas of building construction up to the present time. The difficulty in a building of this sort was to know how to carry the construction through to the street, and he hoped Sir Henry Tanner would show them some day how this concrete building can be continued and honestly given architectural effect. He had seen very successful efforts in Paris, and had no doubt it could be done here, too.

Mr. Max Clarke thought this great object-lesson in reinforced concrete work was particularly useful at the present time, when the regulations which are to govern those who wished to build in reinforced concrete are under consideration. It appeared from the paper that the total cost of the building was 7⅞d. per cu. ft. altogether, which showed it was a remarkably cheap building. Sir Henry Tanner had also calculated the super load at 1 cwt. per ft., which was absolutely new, and not allowed by the County Council regulations ; but architects must forget all they had learned and start afresh, pointing to the Post Office building as a good precedent to follow. He would like to know why Sir Henry Tanner adopted a standard with regard to cement which is different from the British Standard Specification, and also if there was any stipulation as to whether the concrete should be put in " wet " or " dry." Emphasis had been laid in the paper on the amount of care necessary to prevent chips and pieces of wood getting into the columns, which was very important. He thought Sir Henry Tanner's estimate as to supervision should be multiplied by ten.

Mr. J. Ernes Franck.—He would like to know if the walls had been carried from the basement level, or if they were taken right down with separate foundations. He thought Sir Henry Tanner's specification for cement was superior to the usual British Standard quality. Another important point was the question of expansion, but this building was designed so that there would be no fear of expansion of the topmost storey or the roof. He hoped in the next building of this class the reinforced concrete would be brought right through, and that there would be a front elevation in this material, which was one they could construct with, and was therefore one in which a design that was æsthetically sound could be carried out just as in anything else.

Mr. C. S. Meik.—Sir Henry Tanner was in the fortunate position of having a Board who had carried out his designs and wishes, and he had therefore produced one of the finest buildings in London. It was to be hoped that the members of the Royal Institute would have similar opportunities afforded them when the County Council Regulations came into force. Sir Henry Tanner mentioned the factor of safety of the building as being 4 to 1. This was not the case. This was the factor of safety in the steel, and also probably in the concrete, taken separately ; but taking the two combined, he did not think the factor of safety was 4 to 1, because as soon as the steel passed its yield point it stretches, and the beam collapses, owing to the fact that they were not dealing with a homogeneous structure. So that the factor of safety in any reinforced concrete beam was very little more than 2 to 1, whereas in the component parts it might be 4 to 1, or even more. Then, again, the test-block mentioned by the lecturer, of 4 in. cu., was too small ; a reliable test of concrete could not be obtained unless with a cube of 6 in.

Professor Henry Adams congratulated the author on having had the opportunity to construct so large a building ; secondly, that he should have had the wisdom to employ reinforced concrete ; and, finally, that he should have had the skill to carry it out to a successful issue. The retaining walls in the building were only 7 or 8 in. thick, instead of 7 or 8 ft. as they would have been if of brickwork, which showed in a remarkable way the advantages of reinforced concrete that have been obtained in the present case by strutting at the ground level and at the basement level, so that the retaining wall is supported top and bottom, and is only equivalent to a piece of floor slab ; also, the Portland cement was above the Standard Specification, and that would account for the thinness of the floor slabs, which are only 3½ in. thick; by having an extra strong material they were able to get a thinner floor.

Mr. H. H. Statham said he had been inspecting the building that afternoon, and had noticed that one part towards the loading yard had been treated architecturally in concrete—there were the cornice and modillions, and everything just as it might have been in a stone front.

Mr. J. S. E. de Vesian.—In a building such as this it was most desirable to have a contractor who understood the work and who was honest, and also to have careful supervision of the men by Clerks of Works. In this case they had had good fortune in both respects. In every structure, of every class of material, expansion and contraction must take place with changes of temperature. In a monolithic building such as a reinforced concrete structure is, this expansion and contraction took place as it were within itself, but no evil results would follow. This material had been used in tropical climates and all over the world, and in a framed structure of reinforced concrete there need be no fear of trouble arising from changes of temperature. Although the calculated factor of safety was, say, 4, the actual factor of safety in a reinforced concrete building such as this was greater, owing to all parts of the structure working together, which increased the factor of safety considerably.

Mr. Leonard Stokes (President)—Sir Henry Tanner was to be congratulated on having the luck and the capacity to carry out this building in the excellent way he had done. In spite of the advantage of not having the Building Act to worry him, he might have made a much less satisfactory building, and it must not all be put down to the absence of building regulations. He was interested in the thinness of the floors, and would like to know whether sound carries from one floor to another. He was also very much interested in the fact that the chimney stack had been erected in reinforced concrete.

Sir Henry Tanner responding to the vote of thanks, said he could take little credit for the design of the reinforced concrete work which had been done by the late Mr. Mouchel. He (Sir H. Tanner) had restricted the sizes, and directed that the arch beams should not be deeper than necessary, and therefore they had been made more in the way of cantilevers. He thought the alterations of the Building Act would enable them to practically follow the lines taken in the General Post Office—he did not fancy there would be much difference. As to expansion, he could say they had experienced no trouble since the place had been covered in. The floors were very thin, but they had been loaded to twice their nominal load, keeping well within the limit set for deflection. The utmost deflection had been a thousandth part of the span, which was hardly perceptible. As to the question of sound, raised by one speaker, they had not been troubled at all so far. Regarding the factor of safety, it must be borne in mind that concrete trebled in strength, so that in three years there was a very ample margin, and the strain of 50 per cent. on steel is practically never exceeded.

CANADIAN CEMENT AND CONCRETE ASSOCIATION.

HIGHWAY BRIDGE CONSTRUCTION.

Paper by CHAS. TALBOT, County Engineer, Middlesex, Ontario, Canada.

The following is an abstract of a paper read at the Second Annual Convention of the Canadian Cement and Concrete Association.

In Ontario previous to 1874, the bridges on highways were almost all constructed of wood. From 1874 to 1895 many of the larger bridges were replaced with what were then considered permanent bridges. They consisted of quarry stone abutments and piers, costing about $10 (£2) per cub. yd., and iron and steel superstructures with wooden joists, floors and hand rails. In Western Ontario a large number of these were built mostly well designed and well erected, they were built to carry an equally distributed load of 80 lbs. per sq. ft. floor surface, and a concentrated load of five tons on two axles at 10-ft. centres.

Between 1874 and 1891 eighteen of such bridges were erected in Middlesex County—sixteen over the River Thames and two over the Aux Sauble River—at a total cost of $227,000. They were designed with a large factor of safety, consequently they withstand the heavier traffic they are now subjected to, but they are too light to be floored with concrete. About 1896 the first concrete abutments and piers were built. At this time concrete was looked upon as an experiment, and stone work, even at an advanced price, was preferred. Soon, however, concrete was adopted generally, and in 1899 highway bridges were built with steel superstructures, designed to carry concentrated loads of 10 to 15 tons, supported on concrete abutments and covered with concrete floors. At this time they considered these structures permanent, and they are splendid works.

In 1903 short-span concrete arches were built extensively. Then followed, in quiet succession, reinforced arches, reinforced beam bridges, reinforced abutments, until at present reinforced concrete is claimed to be the only permanent job, and whether permanent or not, one thing is sure—that the remaining wooden bridges must be renewed in the very near future, and in their renewal reinforced concrete is going to be used to a very great extent.

Municipalities should employ experienced men to design their work. If the work is done by day labour, employ an experienced foreman, who will follow in every respect the design decided upon and carry out the plan and specifications. In no case should foreman, inspector or contractor alter the engineer's plans. If they discover something incomplete, they should notify those in charge and the engineer should be consulted. If the work is done by contract, an efficient contractor and an experienced inspector should be employed if one can be got; if not, at least get a man who will understand perfectly the plans and specifications and who will follow instructions given.

With an engineer and an inspector who understand their work, and a good contractor, the success of the undertaking is assured. There is absolutely no doubt as to the effectiveness of reinforced concrete when properly handled. Notwithstanding this, there are a few jobs erected from plans prepared by me that are as complete as I would wish; in strength they are all that I expected: but their finish is not artistic. Out of the large number of structures I have designed, few indeed are finished in accordance with the plan they were supposed to comply with. Only in two or three instances has the details of the finished work corresponded to the plan. The difficulty is the lack of inspectors who understand the plan, and of contractors who understand the work, but the men are improving, and this year I hope for much better results.

I have said little or nothing about the advantages of concrete. At this stage of its development, its usefulness is universally admitted. I do not consider it as being in opposition to steel structural work, each is incomplete without the other, and an experienced engineer on highway work can readily determine whether a steel superstructure, an arch or a reinforced concrete superstructure could be most advantageously used.

Under exceptional conditions long-span arches can be used within reasonable cost. In my practice I have used reinforced concrete slabs up to 16-ft. span; reinforced concrete beam bridges up to 36-ft. span, and reinforced concrete arches up to 75-ft. span. Steel superstructures with concrete floors and concrete substructures in spans from 20 ft. to 240 ft.

Since 1901, Middlesex County has spent $189,400 (£39,880) on bridge work alone. In every structure erected concrete has been used, and has given complete satisfaction. The first concrete floor laid (1902) is as perfect as when the maker left it.

I believe it is not in the interests of cement manufacturers or concrete workers to attempt to compete in price with steel highway work. The properly designed, well erected and artistically finished reinforced concrete structure is so much superior to the ordinary steel bridge that there should be no comparison in first cost. In my opinion it is this unequal competition that is causing the failure in concrete structures in that on spans of any considerable length the designer cannot compete with steel under present conditions and allow sufficient factor of safety. A superior article commands a superior price. Just as the old wooden bridge was not abandoned because timber became scarce and expensive, but because the people demanded a superior article at an advanced cost, so steel bridges, to a certain extent, are being superseded by reinforced concrete, not because it is less expensive, but because its durability is established.

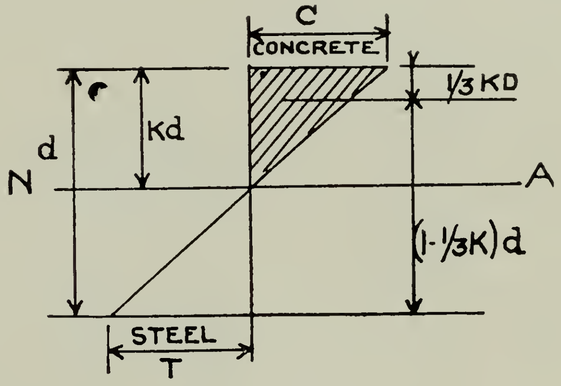
Were I to offer advice, it would be to continue to adopt the designs in bridge construction that come the nearest to permanent structures, even at an advanced price. It is well known that both steel and concrete bridges are being designed and erected by the score of men who have neither scientific nor practical knowledge of the subject. Taking this into account, and also the fact that reinforced concrete has been in use but a short time, the wonder is that more structures, especially of concrete, have not failed. The public should be protected from this danger, and the least the Legislature could do, and what there is great necessity for their doing, is to establish some central supervision of all highway designs before they are permitted to be used.

ECONOMICAL "FERRO" CONCRETE.

By MR. G. A. CLARK.

The following article, by Mr. Geo. A. Clark, appeared in a recent number of the magazine of the Old Students' Association, Finsbury Technical College:

Economical "Ferro" Concrete.—It may have occurred to many old students that the design of reinforced concrete work is, to a certain extent, conducted in a haphazard manner. Especially is this noticeable when the reinforcement is roughly estimated before the stresses are found, and should the estimate be incorrect the process has to be repeated. In the case of simple floor slabs this may be obviated by using the formulæ deduced below, which may prove useful to many Finsburians, as, indeed, they have to the writer :



Let m = ratio of the Moduli = $\frac{\text{E steel}}{\text{E concrete}}$ = say 15

d = depth of steel below top surface.

Kd = depth of Neutral Axis.

b = breadth of slab.

C = compression stress (Maximum).

T = Tensile stress.

p = ratio of $\frac{\text{area of steel.}}{\text{area of concrete.}}$

Then—

$$\frac{mC}{T} = \frac{Kd}{(1-K)d} = \frac{K}{1-K} \qquad (1)$$

But total tension = total compression $\therefore$ $pbdT = \frac{C}{2}bKd$

$$i.e., \ cK = 2pT. \qquad (2)$$

Substituting value of T from equation (1)

$$K = \sqrt{(p^2m^2 + 2pm)} - pm$$

The above formulæ were taken from the R.I.B.A. Report.

Now the floor slab is only doing its work economically when both steel and concrete are stressed to their allowable stresses at the same time—namely, 600 lb. for concrete and 17,000 lb. for steel. If these values are substituted in equation (1) we get the correct depth of the Neutral Axis in terms of the depth of the slab.

$$\frac{mc}{T} = \frac{K}{1-K} = \frac{15 \times 600}{17{,}000}$$

$$K = \cdot 346 \qquad (3)$$

The arm of the stresses—*i.e.*, the distance between the centres of compression and tensile stresses—may now be found, and is equal to $d(1-\frac{1}{3}K) = \cdot 8846d$.

The ratio of steel to concrete may also be obtained by substituting the values in equation (3).

$$K = \sqrt{(p^2m^2 - 2pm)} - pm$$

$$\cdot 346 = \sqrt{(15^2p^2 + 2 \times 15p)} - 15p$$

$$(\cdot 346 + 15p)^2 = 225p^2 + 30p \qquad (4)$$

$$p = \cdot 0061$$

This ratio of steel to concrete never varies in an economical slab, and is a fixed value. The depth of the N.A. and the arm of the stresses are also fixed.

The results may now be summarised :

$$\left.\begin{array}{lcl} \text{ratio of steel to concrete} & = & \cdot 0061 \\ \text{depth of N. A.} & = & \cdot 346d \\ \text{stress arm} & = & \cdot 884d \end{array}\right\} \text{fixed values.}$$

The bending moment = area × average stress × arm of stress

$$M = b \times \cdot 346d \times 300 \times \cdot 884d \times \frac{1}{2240}$$

$$M = \frac{300 \times \cdot 884 \times \cdot 346bd^2}{2240}$$

$$d = \sqrt{\frac{BM}{\cdot 041 \times b}}$$

and considering 12 in. breadth of slab

$$d = \sqrt{\frac{BM}{\cdot 494}} \qquad (5)$$

and steel = pbd = 12 × ·0061 × *d*

= ·0732d (6)

Example.

Floor, 6 ft. span. Load, 2 cwts. per sq. ft. inclusive.

Load on 12 in. strip = 6 × 1 × 2 cwts. = ·6 tons

B.M. say $\frac{WL}{8} = \frac{\cdot 6 \times 72}{8}$ = 5·4 inch tons

Depth of steel $\sqrt{\frac{5 \cdot 4}{\cdot 494}}$ = 3·3

Steel = ·0732 × 3·3 = ·241 sq. in.

Say overall depth of slab = 4¼ in., and steel bars = ⅜ in. every 5½ in.

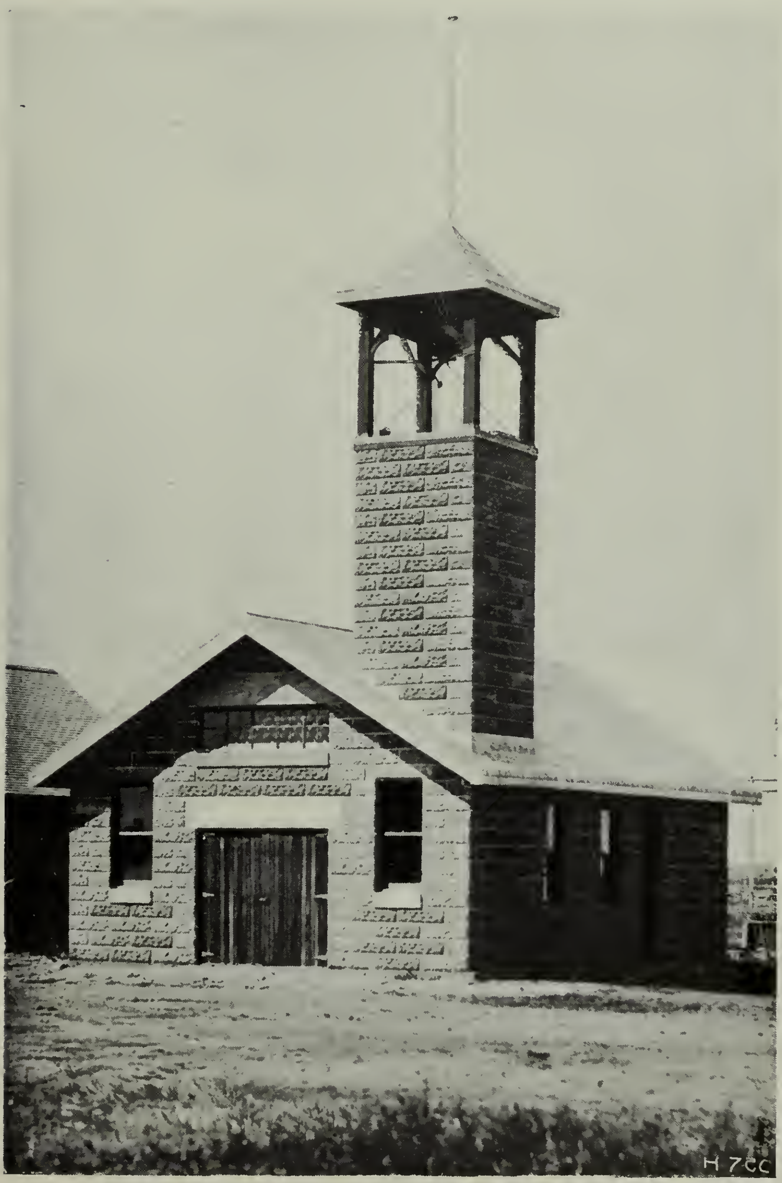
The extreme simplicity and accuracy of the formulæ above (relatively) will no doubt be recognised by many who have to deal with the design of reinforced concrete.

NEW WORKS IN CONCRETE
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

CONCRETE BLOCKS FOR BUILDING PURPOSES.

THE adoption of Concrete Building Blocks instead of stone or brick is gradually but surely gaining ground in all parts of the world. We illustrate in this number two buildings, recently completed, which have been erected throughout with blocks made on the "Winget" Concrete Block-Making Machine.



Built of "Winget" Concrete Blocks.
FIRE HALL AT SEDGEWICK, ALBERTA, CANADA.

The first illustration shows a "Fire Hall," or what we would term a "Fire Brigade Station," at Sedgewick, Alberta, Canada. It is not of any great size, but a most interesting point in its erection is that some of the blocks were laid when the thermometer was 20° below zero. The building, which was then partly completed, was saturated with water and frozen solid. The work was exposed in an unfinished condition without a roof during all the winter, and the blocks are still in perfect condition, not being damaged in any way.

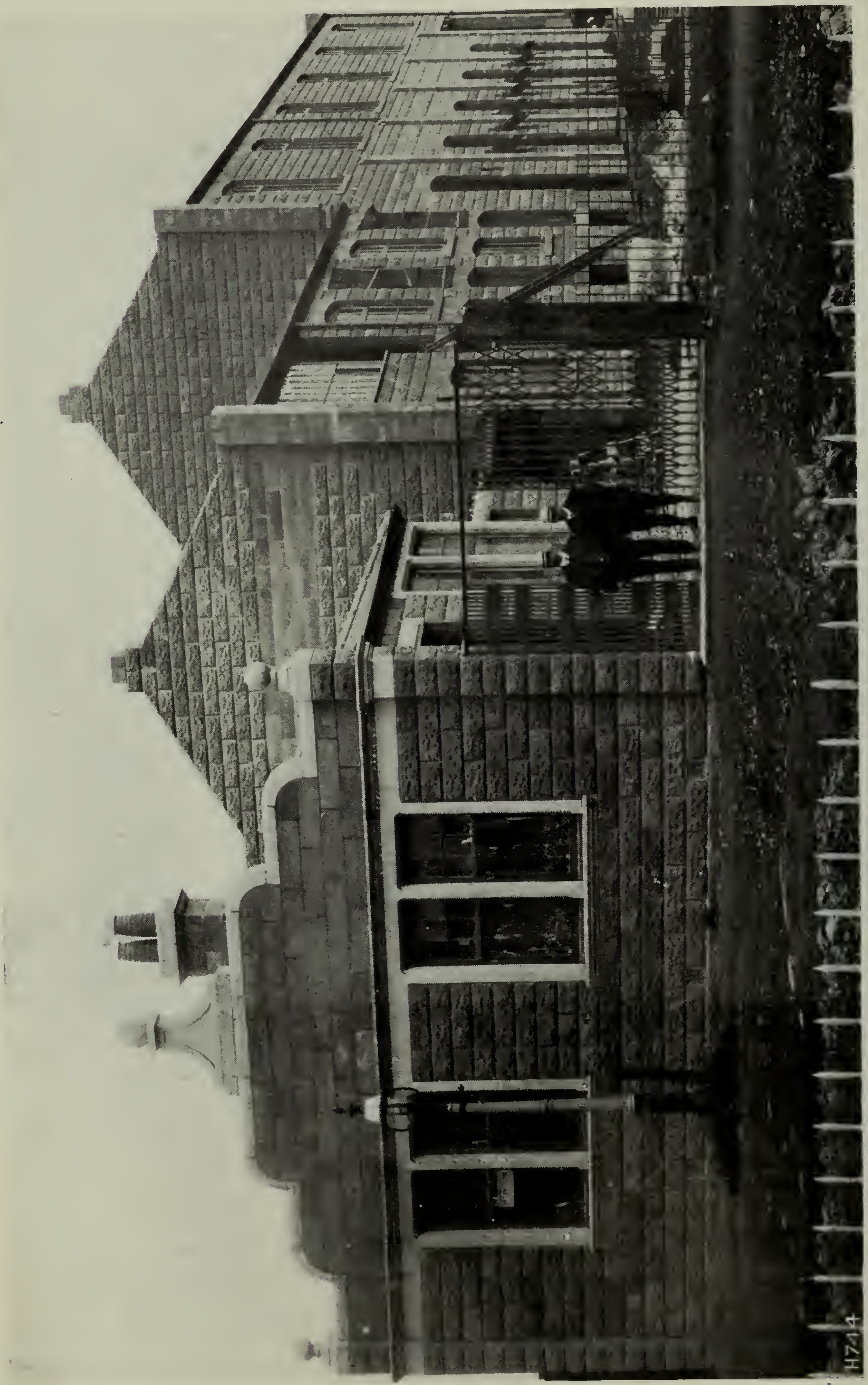
To those who know the extremely severe winter conditions of Western Canada, this should prove without doubt that concrete blocks are equal to withstanding the effects of any frost likely to be met with in the British Isles.

The illustrations we show on pages 142 and 143 are two views of buildings erected by the Fleetwood Granite Co., Ltd., at Fleetwood. They are also built throughout of blocks made on the "Winget" Machine, and the offices are specially designed and equipped as a Builders' Merchants' yard and Stone Crushing and Concrete Manufactory.

The large block of buildings is 208 ft. in length by about 30 ft. wide. The shed adjoining is 60 ft. in length by about 25 ft. wide.

The large block contains a suite of Offices, Stores and Stable; also Concrete Making Shop, with bins to hold crushed granite, and shoots therefrom to load railway wagons or carts alongside.

The buildings present a most agreeable appearance, and have a substantial and useful look. They have proved most satisfactory to the Company who have reected them, and are designed with a view of providing a general Builders' Merchants' yard, along with an up-to-date Concrete Block, Concrete Flag, and Artificial Stone Works.



Built entirely of "Winget" Concrete Blocks.
Offices of Fleetwood Granite Co., Ltd.

REINFORCED CONCRETE IN THE CONSTRUCTION OF THE SHAFTESBURY HALL, PORTSMOUTH.

An interesting example of reinforced concrete construction applied to theatres was carried out at Shaftesbury Hall, Portsmouth, where a gallery, erected on the Lock Woven Mesh System, was completed about eight months ago at this hall which supplied a splendid illustration of the fact that reinforced concrete is well adapted for the construction of theatre galleries. The structure was designed by A. E. Tutte, Esq., of 58 London Road, Portsmouth, whose report is embodied in this article.

The gallery is on a sweep, the centre of which is at the curtain line. At the ends of the front there are reverse curves to the wall. There are 310 tip-up seats arranged with two gangways leading straight up to the exits. There are twelve rows of stepping with a rise to each of 9 in. and a width of 2 ft. 6 in. At the back, in the two corners, small raised platforms 12 in. above the landing level provide accommodation for four seats each. Greater rise could not be obtained to the stepping as the total height in the front of the building was limited by fixed circumstances. Two reinforced concrete beams running the whole width of the building, with a clear span of 41 ft., form the main support of the front portion ; and staircase walls, with beams between same, form the supports at the back.

Another View of Fleetwood Granite Co.'s Works.

The portion beyond the front main beam was cantilevered, and the front of the gallery itself was formed with concrete 3 in. thick, reinforced with Kahn bars and Lock Woven Mesh. As soon as the forms were removed, and before the main centering was struck, the front was ready to receive the fibrous plaster enrichment, bookboard, etc.

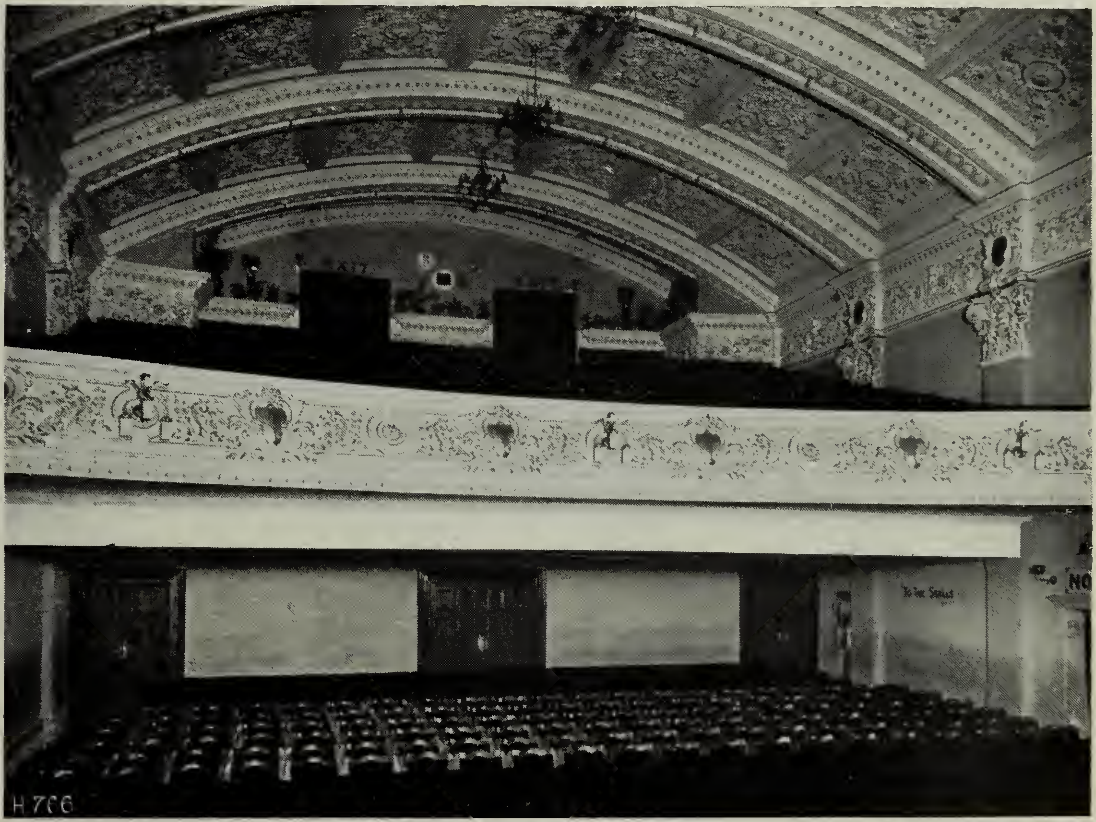
The main beams consisted of concrete reinforced with a combination of plain and Kahn bars. These beams were $34\frac{1}{2}$ in. and 36 in. in depth, and 18 in. and 27 in. in width respectively. On these a 6-in. slab to the required rake was formed with reinforced concrete, and while this concrete was green, breeze concrete stepping was formed upon it for the seats. In the gangways intermediate steps were formed of the same material. In this case the necessary wood forms for the risers were wrought and left in position, the top being covered with boarding, as it was felt by the proprietors

THE SHAFTESBURY HALL, PORTSMOUTH.

that concrete would be cold to the feet, although the whole was eventually covered with carpet.

In addition, the wall at the back of the gallery, the walls of the cinematograph box, and the steps thereto, up to the level of the floor of the box, were constructed of reinforced concrete, and formed practically one monolithic mass with the gallery. Above the level the walls were formed with breeze concrete blocks, partly for lightness, and partly for speed of erection, and because very great strength was required, and the blocks were dry when erected. The whole work was carried out in about six weeks, the centering being allowed to stand for four weeks beyond this period while the roof was being put on the building, the walls plastered, and such work carried out. As soon as the centering was removed, the underside, including the beams, was plastered with cement.

It surely speaks well for the material that although the gallery has been repeatedly loaded to excess there is not a crack in the plaster work. The cost worked out cheaper than steel construction after taking into account the filling in with concrete, which would have been necessary in this case for fire-resisting purposes, etc.



Reinforced Concrete Gallery at the Shaftesbury Hall, Portsmouth.

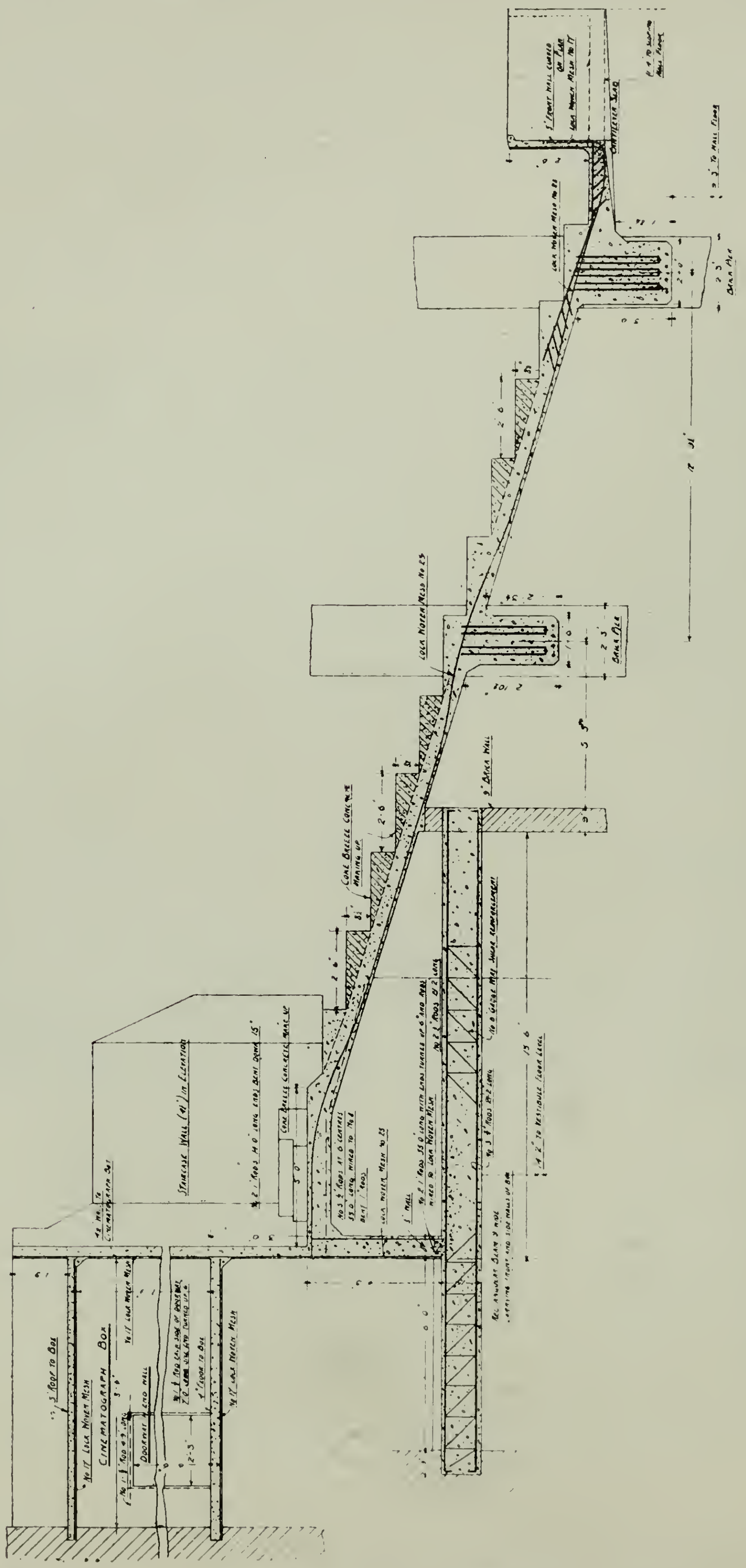
There is no doubt that with steeper slopes for sighting, as can usually be obtained in theatres and music halls, a combination of beams and cantilevers carried out in reinforced concrete would form an ideal arrangement at once economical, fire-resisting, and quickly erected. There is a compactness about the whole thing, from the trades employed to the construction itself, which convinces me that there is a great future before the material for this class of work.

The whole of the reinforced concrete work was carried out by Messrs. James H. Tozer & Son, of York Street, Westminster.

REINFORCED CONCRETE BRIDGE AT MOORGATE STREET, BLACKBURN.

A remarkably successful test was carried out on the 22nd ult., on a new reinforced concrete bridge over the Leeds and Liverpool Canal at Blackburn. A view of the finished structure is shown in the illustration on p. 148, and we also reproduce, on page 147, a drawing showing plan and sections of the bridge.

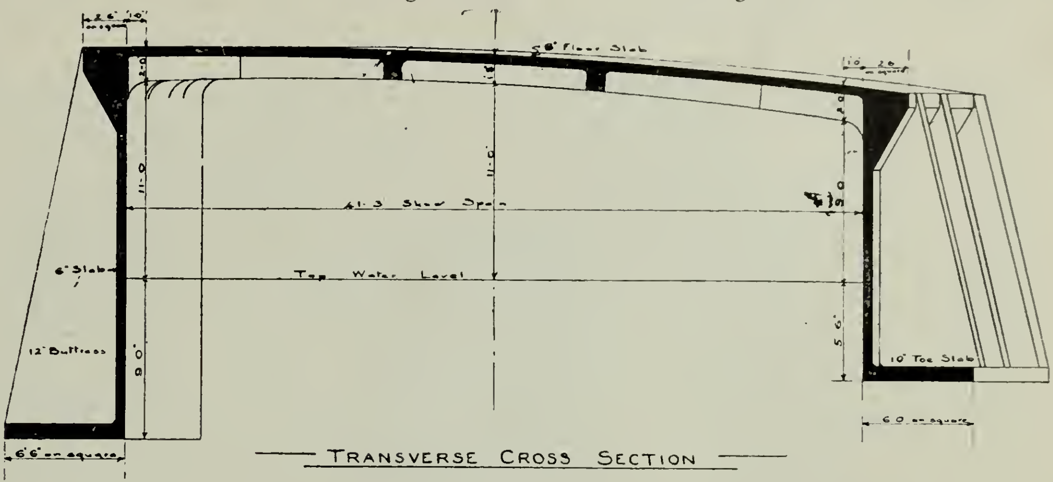
The new structure was erected to replace an existing arch. Both the width of


Cantilever Slab
9" Brick Wall
Coke Breeze Concrete Making up
Staircase Wall (4½") in Elevation
Cinematograph Box
Doorway

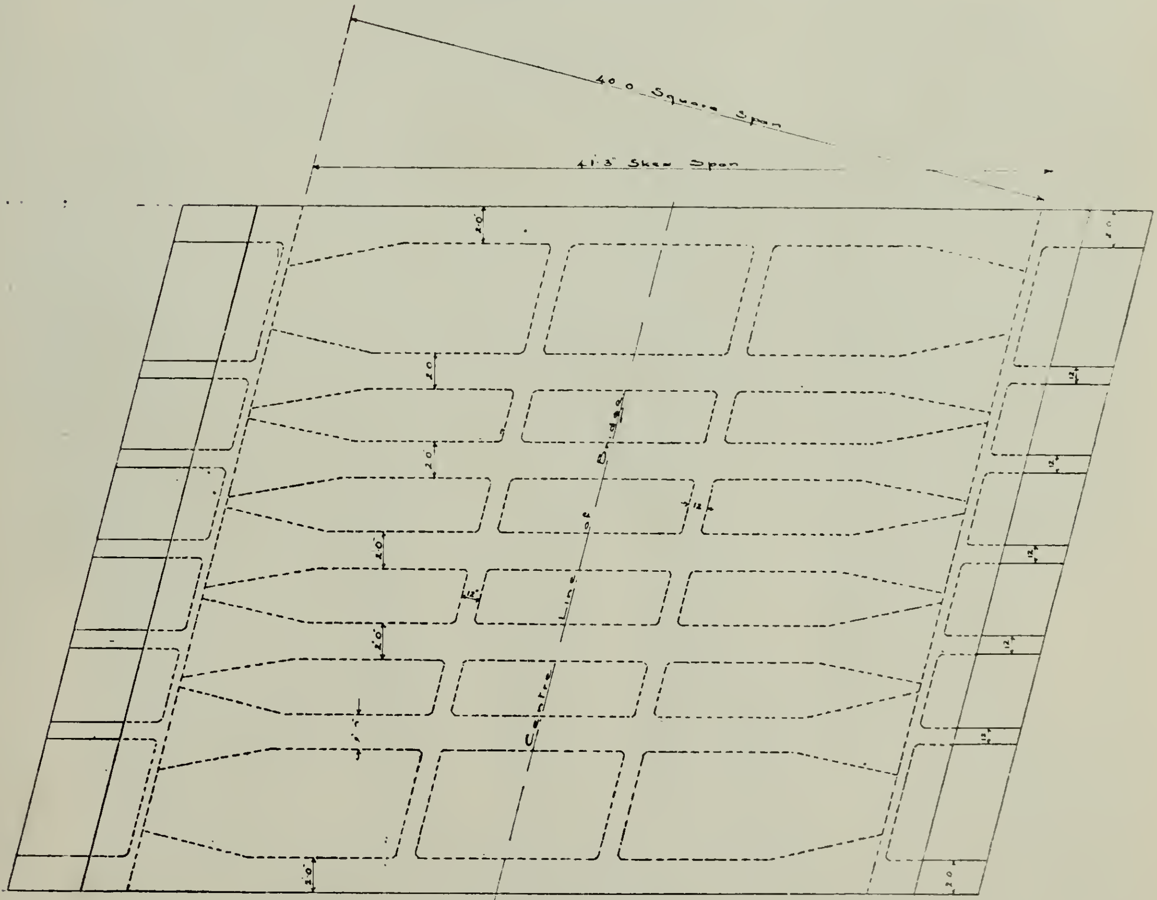
Cross Section through Gallery and Cinematograph Box.
Shaftesbury Hall, Portsmouth.

the roadway and the span of the bridge were greatly increased, in order to afford additional facilities to both the road and canal traffic. The span is now 40 ft., and the width of the roadway 37 ft. between parapets.

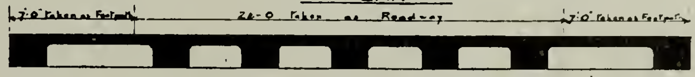
Owing to the situation of the bridge exceptionally heavy loads had to be provided for, and the test consisted of a moving load of not less than 65 tons.



TRANSVERSE CROSS SECTION



PLAN

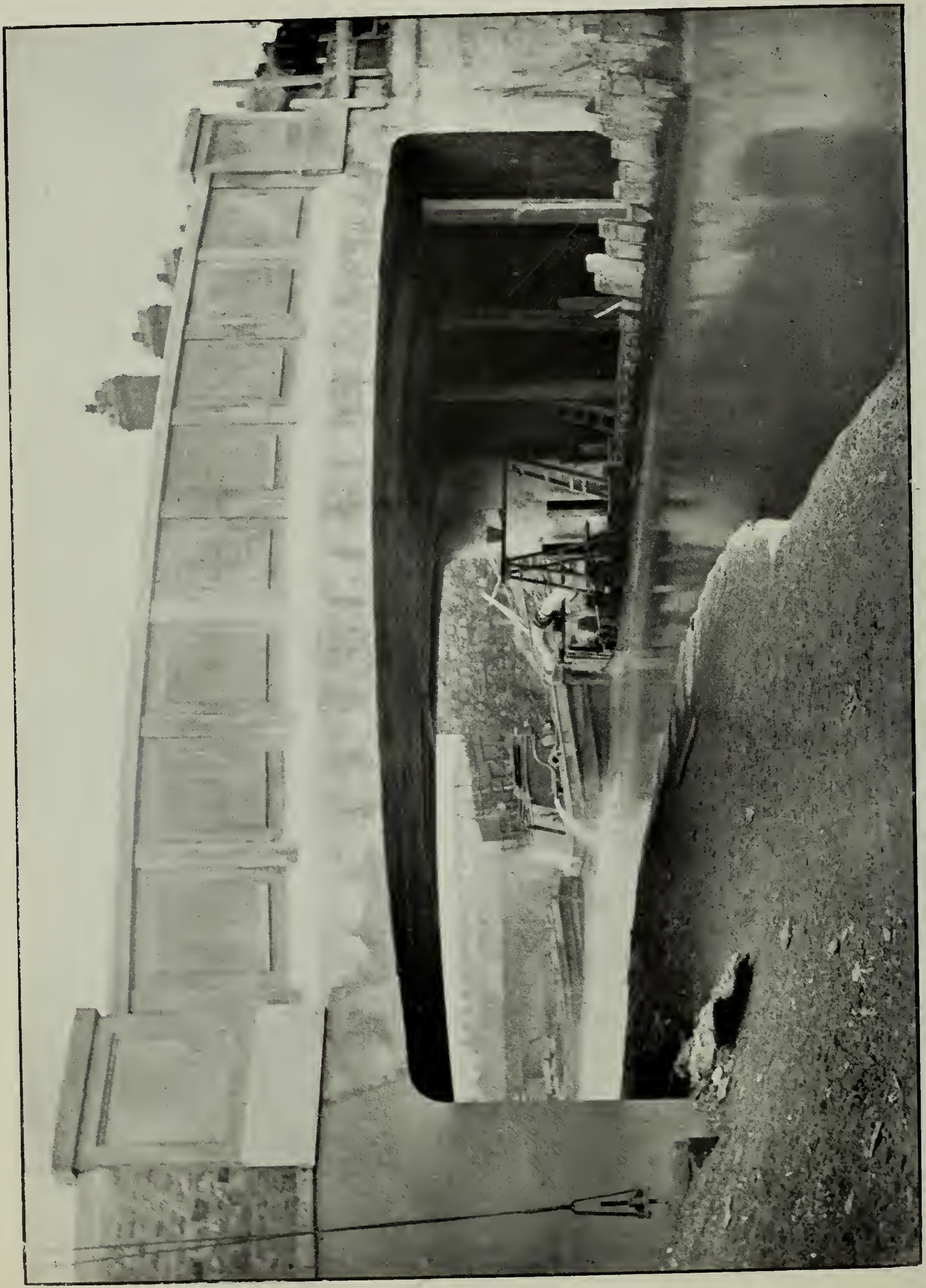


SECTION ON SQUARE

Plan and Sections.
Reinforced Concrete Bridge at Moorgate Street, Blackburn.

The test was made with a 14-ton traction engine drawing an 18-ton 4-wheel bogey (No. 1), and a 15-ton engine drawing a 32-ton 4-wheel bogey (No. 2). The test was first made by passing No. 1 engine and bogey over the bridge, the load being 32 tons. Bogey No. 1 was then left on the bridge, and engine and bogey No. 2 were passed over alongside it, the total load being 65 tons as stated. In neither case was there the slightest measurable deflection, and the vibration during the passage of these exceptionally heavy loads was practically imperceptible.

This bridge was designed by the Patent Indented Steel Bar Co., Ltd., and was constructed under their supervision by Messrs. F. Mitchell & Sons, contractors, Manchester, indented bars being used in the reinforcement throughout. The structure affords an interesting example of the advantages of reinforced concrete, as in addition to the economy effected, the rise allowed was very slight, only 1 ft. on a span of 40 ft., owing to the necessity of avoiding interference with the road gradient. It



View of Finished Bridge.

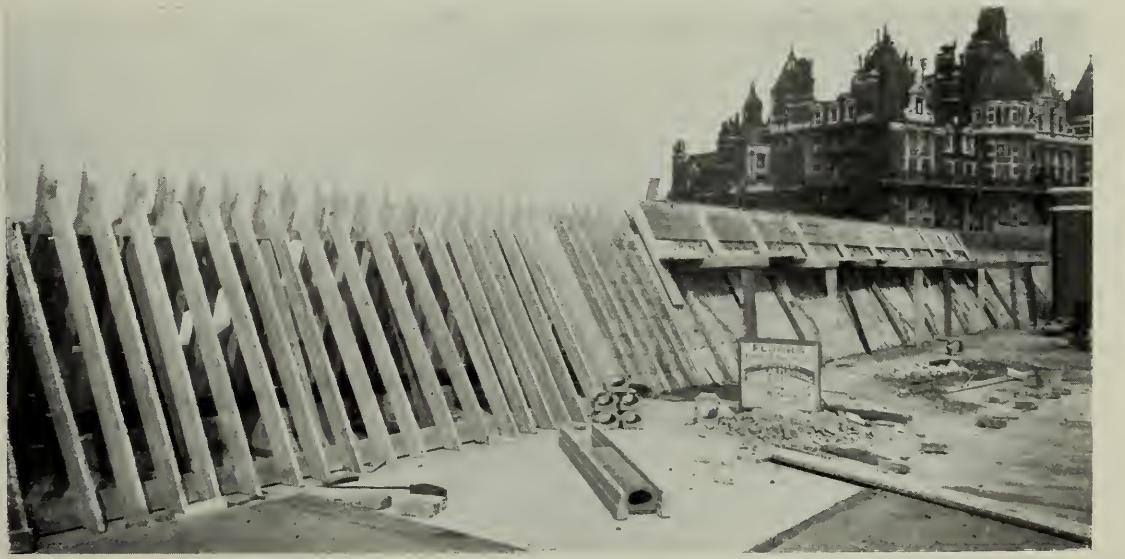
Reinforced Concrete Bridge at Moorgate Street, Blackburn.

would have been difficult, if not impossible, to construct a bridge in any other material which would have given such flat gradients in the roadway, and at the same time such headway above the canal.

The engineer for whom the work was constructed was Mr. W. Stubbs, Assoc.M.Inst.C.E., Engineer to the Corporation of Blackburn, under whose personal supervision the test was carried out. There were present at the test: Mr. Jos. Fielding, Chairman of Highway Committee; Mr. W. Kenyon, Vice-Chairman of Highway Committee, and other gentlemen officially interested.

SCREEN ROOF AT IMPERIAL COURT, KNIGHTSBRIDGE.

At the recent opening of the Architects' Technical Bureau Exhibition, Sir Aston Webb in his speech called attention to the great extent to which the field formerly filled by the carpenter and joiner had been invaded and occupied by the engineer and reinforced concrete specialist. We illustrate an example of such an adaptation of carpentry principles by the latter, in the formation of a screen roof 140 ft. in length, with two sloping faces, recently completed by the Armoured Tubular Flooring Co., Ltd., at Imperial Court, Knightsbridge, where some 250 sq. yds. of such concrete roofing were constructed with the absence of centering, enabled by the design adopted by this firm.



Roof in course of construction.
Screen Roof at Imperial Court, Knightsbridge.

The face slope of 75° to Brompton Road and inner slope of 60° were formed of reinforced concrete rafters of 6 in. depth laid against centre ridge rail shown, to correct line and slope, and were uniformly spaced by hollow concrete tubes; the feet of rafters and their junction at ridge were made good in mass concrete binding all together as shown, slating battens nailed to surface support the usual graduated slating. This construction is carried by reinforced concrete roof flats of 21 ft. span, which in common with other flooring throughout this building were constructed upon the Armoured Tubular system.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE LOCOMOTIVE COALING STATION AT HAYESVILLE, OHIO, U.S.A.

REINFORCED concrete is an admirable material for locomotive coaling stations. These stations must be located on the railway, very often spanning the main line, which indicates the suitability of reinforced concrete, or that, if steel is used, it should be fireproofed with concrete. Such a station must also withstand the gases from the locomotives which stand beneath it. In a concrete station the cost of maintenance is for the machinery only, which amounts to about one-quarter to one-third of the cost of the entire plant. Moreover, the danger of complete destruction by spontaneous combustion, which occurs in storing bituminous coal, especially on account of the dead coal left in the corners of the pocket, is eliminated ; although the contents of the pocket may be consumed, the structure would probably be saved.

One of the most recent of these stations was built by the J. M. Dodge Co., Nicetown, Pa., U.S.A., for the Norfolk & Western Railroad at Hayesville, Ohio. This station spans the main line, and was built without interfering with the traffic. It supplies both sand and coal to the engines, and spans five tracks.

The whole station is supported on four girders spanning a conveyor pit 15 ft. wide, through which the conveyor runs, carrying the coal up into the pocket. These girders are 2 ft. wide and 10 ft. deep. They are designed as beams, giving 6 ft. 6 in. clear headroom from the floor of the conveyor tunnel, and carry the concentrated loads of the columns. The construction over the foundation supporting the road-bed consists of 85-lb. rails, placed side by side, parallel with the tracks and embedded in a 6-in. concrete slab. Under each rail four extra inverted rails are placed. The ballast is placed on top of this slab. The whole construction is supported at the centre of the pit between conveyors by 20-in. 120-lb. girder beams, and 8-in. I-beam columns.

The track hoppers are 12 ft. square, spaced 25 ft. 2½ in. on centres, and each feeds a conveyor.

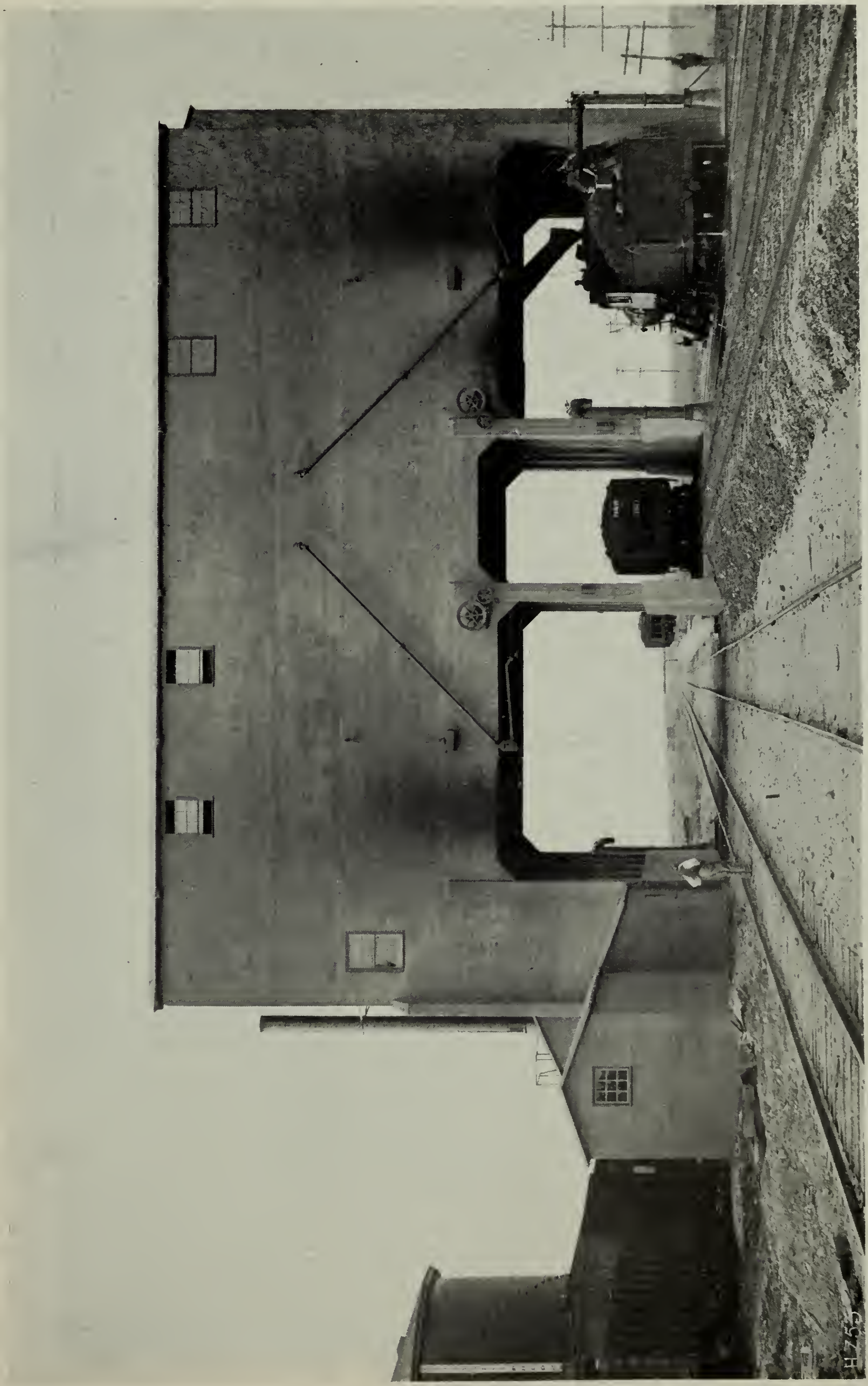
The pocket is designed for 880 tons of bituminous coal, on the basis of 40 cu. ft. per ton. It is made up of slab and buttress construction. The walls are 6 in. thick at the top and 13 in. at the bottom, with buttresses 15 ft. on centres. The pocket walls are 30 ft. by 75 ft. 6 in. outside and 20 ft. deep, with no ties between top and bottom. The upper reaction of the buttresses is taken by a girder, which also supports the conveyor floor and spans 30 ft. across the pocket between buttresses on each side. The floor of the pocket is made of 9-in. slabs, supported on longitudinal girders 16 in. and 24 in. wide by 59 in. deep, which span 29 ft. over two sets of coaling tracks, and by girders 12 in. and 16 in. wide by 30 in. deep, spanning the single dumping track.

To gain access to the conveyor floor a stairway is provided just outside of boiler house. The stairway has 8-in. channel sides, with 2-in. oak treads between them, and a 1¼-in. handrail. This stairway enters the building at the boiler-house roof, and from here, by four succeeding flights, reaches the conveyor floor.

For the convenience of the operator to get into the conveyor pit under hopper and tracks a concrete stairs, with carborundum treads, is provided, and leads directly down into the pit, between the conveyors, to the engines which operate the feeders under the hoppers.

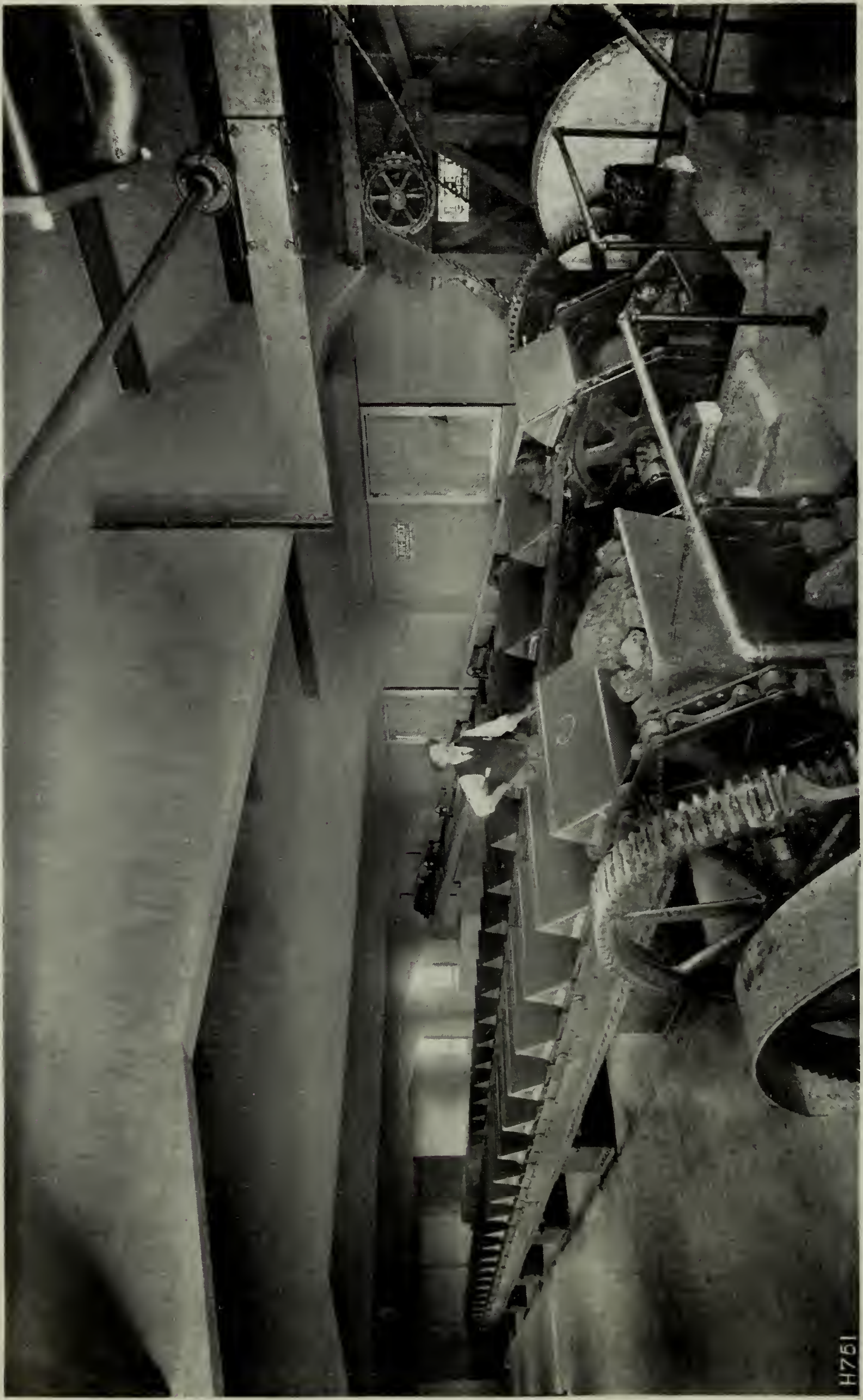
Casings are provided at the vertical runs of the coal conveyor at each end of the building. These and side walls of the lantern are made of Hy-rib, plastered on each side, and supported on light steelwork.

All reinforced concrete above foundations was made in the proportions of 1 part cement, 2 parts sand, and 4 parts crushed stone. The following stresses are not exceeded: Concrete in compression, 600 lb. per sq. in.; steel in tension, 16,000 lb. per sq. in.; ratio of modulus of elasticity of concrete to steel, 1 to 12. After test borings were made by the railroad company it was found that the soil was of such a nature that the loads imposed thereon should not exceed 7,000 lb. per sq. ft.



Reinforced Concrete Locomotive Coaling Station at Hayesville, Ohio, U.S.A.

Particulars of the work are taken from the *Engineering Record*, and the illustrations were kindly placed at our disposal by the Link Belt Co., of Philadelphia, by



View showing interior construction.
Reinforced Concrete Locomotive Coaling Station at Hayesville, Ohio, U.S.A.

whom all the machinery for the coaling station was furnished.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the past year.

"The Chemistry & Testing of Cement." By Cecil H. Desch, D.Sc.

Published by Edward Arnold, London. 1911. 10/6 net.

Contents.—The History of Calcareous Cements.—The Raw Materials and Processes of Manufacture of Cements.—The Chemical Components of Cements.—The Constitution of of Cements.—The Setting and Hardening of Cements. — The Physical Properties of Cements.—The Mechanical Properties of Cements.—Concrete and Artificial Stone.—The Resistance of Cement and Concrete to Destructive Agents.—The Chemical Analysis of Cements.—Conclusion.—Appendix I. : The Revised British Standard Specification 1910 ; Appendix II. : Chronological Table.

The manufacture and even the use of Portland cement is increasingly recognised as a matter for the expert chemist rather than the engineer, and for this reason this book is a welcome addition to existing literature on the subject, as written from the chemist's point of view. The author presents, in compact form, the conclusions drawn from the most recent researches on the constitution of Portland cement ; and in the chapter devoted to a consideration of the setting and hardening phenomena, adopts Michaelis's colloidal theory in preference to that of interlocking crystals. This chapter, together with that on the chemical constitution of cement clinker, is perhaps the most valuable part of the book There are also useful chapters on the physical properties and the analysis of cements, as well as on concrete and reinforced concrete, and their resistance to destructive agents such as sea-water, fire, and sewer gases. The importance of fine grinding is lucidly explained, and, in discussing the effects of aeration upon cement, we notice that the author's opinion is in agreement with Mr. H. K. G. Bamber's contention, recently put before the Institution of Civil Engineers, that, with modern cement aeration is entirely unnecessary. The use of coke-breeze, slag, and slag cements containing sulphides in concrete construction is also touched upon, the conclusion being that Portland cement only is suitable for reinforced concrete work. In his remarks upon the effect of clay in concrete, however, we think the author's conclusion that the presence of clayey matter is harmless, is not quite correct. There is a considerable difference in the respective influence on strength of *dry* clay and of wet clay as it exists in natural sand.

The book contains some excellent photomicrographs and other illustrations, is well written, and can be confidently recommended.

Standard Specifications for Structural Steel, Timber, Concrete and Reinforced Concrete. By John C. Ostrup, *Professor of Constructional Engineering, Stevens Institute of Technology, M.Am.Soc.C.E., M.Inst C.E.*

Published by McGraw-Hill Book Co., 239 West 39th Street, New York. London Agents—Hill Publishing Co., 6 Bouverie Street, London, E.C. Price 4/6 net.

Contents.—Part I., Steel Framework of Buildings ; Part II., Highway Bridges ; Part III., Railroad Bridges ; Part IV., Plate Girders ; Part V., Materials and Workmanship ; Part VI., Inspection, Painting, and Erection ; Part VII., Structural Timber ; Part VIII., Cement ; Part IX., Portland Cement Concrete ; Part X., Reinforced Concrete.

There is a tendency in the United States to provide standard specifications for all kinds of work. We can well understand a standard specification for steel and cement and the manufacture of concrete, but what American engineers call a standard specification for structural work is more in the nature of a set of general conditions for competition in design and tendering. Thus, for instance, in the specification, included in this book, dealing with the steel framework of buildings, it states what shall be considered the dead load and what is to be assumed as the weight of roof covering, what shall be assumed as the weight of purlins and roof trusses, allowance for snow load and wind pressure, live loads and impact stresses, bearing power of piles, design of framing and details of design, such as spacing of rivets, etc. Indeed, the whole is much in the nature of municipal regulations. To architects and engineers in England, however, a specification could not well be standardised except in respect to materials, for the way we look at the matter is that the specification shall be a description of the particular work in hand, simply instructing the contractor in the work he has to do, and the designer gets his information for such purposes from various sources, among which are aid-books of various kinds. These American "specifications" are a sort of cross between regulations and the data furnished by such books as "Molesworth" and "Hurst" without giving even the meagre explanations that are contained in such pocket-books. In our opinion it would be far preferable if the Americans discarded their great fondness for such summaries of data which they call "standard specifications," and were to put such information in the form of detailed reports giving reasons for their emphatic statements. We find them allowing considerable variation in many respects between limits of stress and loads, as, of course, they must do where there is such great variability in structures. Surely in such a case it would be better to have some little explanation as to how one should determine the best value for adoption in certain circumstances. Such explanatory reports, if drafted by committees of experienced and able theoreticians, would be very valuable, and of much greater service than such snippy documents as these. The specification for cement which is included is that of the American Society for Testing Materials, while that for Portland cement concrete is the standard adopted by the American Railway Engineering and Maintenance of Way Association. As, however, this was adopted in 1904, it is somewhat out of date, and we are surprised that the author should have included it ; it is very short and not nearly sufficient. For instance, in reference to mixing by machinery, the adoption of a batch mixer, which compels the concrete to be mixed in batches, should be insisted upon. The proportions are not dealt with, and such items as waterproofing and precautions in freezing weather are all left in the elementary stage. The specification for reinforced concrete is much fuller and much better, though it mostly deals with the design, and the clauses relating to materials and workmanship and inspection could be improved upon.

On the whole, we cannot say that we are much impressed with the book. We do not see that it serves any really valuable purpose. What it contains is obtainable from other sources within the reach of most of those to whom such a book would appeal. Where the specification has been drafted by persons of experience and some authority it is deserving of consideration, but where the specifications have been drafted by the author entirely the dicta of one man cannot carry so much weight.

Masonry and Reinforced Concrete. By Walter Loring Webb and W. Herbert Gibson, B.S.

Published by The American School of Correspondence, Chicago. London Agents—Crosby, Lockwood & Son, 7 Stationers' Hall Court, Ludgate Hill, E.C. Price 12/6 net.

Contents : Masonry and Concreting Materials.—Stonemasonry and Plain Concrete Construction.—Reinforced Concrete.

The number of books on reinforced concrete are becoming fairly numerous, but the latest addition to the list, which we now have under review, is somewhat different in form from those which have been published before. It belongs to the class of handbooks issued by correspondence schools, and it has the ordinary advantages and disadvantages of such a method of treatment. These books are designed to teach the student without the aid of the verbal instruction of a teacher. They have therefore to be very lucid and profuse, and are arranged in such a way that they can be divided up into lessons fitting the capacity of the student. The instruction is therefore of a piecemeal character, and though much useful information is included the book cannot be quite so suitable for reference or consultation as a complete treatise which can be consulted by advanced students and practitioners. At the same time it is somewhat difficult to teach such a subject to the elementary student, and much of the advanced knowledge which would lead to an adequate understanding of the subject has to be omitted. It is here that verbal instruction is superior, because the student can be more thoroughly taught and the whole relationship of the subject can be kept before him. The advantages of the correspondence method of teaching is that students can receive instruction at their convenience and in places where they are precluded from obtaining personal instruction, and when they have a good grounding in building construction and engineering they can more readily derive benefit from such books. These advantages apply particularly to reinforced concrete, where at present the facilities for obtaining personal instruction are small.

It strikes one as rather strange, until one is used to American practice, that this book should be called "Masonry," because in the United States they call both brick, stonework, and concrete by that name, whereas we limit that term to stone. However, the book is not quite what one would suppose from the title, because there is not very much in it about stonework, and still less about brickwork—by far the greater part deals with reinforced concrete. It is a pity that this volume should not have been devoted to reinforced concrete alone, the other subjects being so cursorily dealt with, and we feel that the student would have surely preferred to have the volume deal with the one subject alone.

So far as the book goes the subject has been dealt with very well. We are surprised that a more obvious notation was not used for the calculations. The calculations are very simply explained, but we think that elementary students will find some little difficulty in following them We are sorry to see the calculations for practical service put into the form of tables ; it would have been better to have arranged them as graphs, so allowing more variation to meet different conditions. The calculation for shear stresses is not at all well done, and the student of this book could not be trusted to design large beams in practice without more experience or ability to prove that he was competent to work the thing out for himself. The treatment of retaining walls is so old as to be almost useless in the practice of designing. The designer is not sufficiently catered for, the treatment of the subject generally being more suitable to those who desire to have a rudimentary knowledge of the manner in which such a structure is made, and not for those who wish to design such work. The practical notes are much more to the point, and would prove a more adequate equipment for the superintendent. Of course, such practical information is equally important to the designer, who, to be efficient, must be familiar with practical conditions. We are rather surprised that the book, instead of containing so much scrappy information on stone and brickwork, did not occupy the available space by including some practical notes on plain concrete work. The inclusion of such information would be of far more advantage to the purchaser of the book. A certain amount of information on this, it is true, is included, but it only whets the appetite, and in that respect it certainly fulfils its object, for it ought to lead the student to go further into the matter and to study more complete and advanced works.

Lockwood's Builders' & Contractors' Price Book, 1911.

Published by Crosby, Lockwood & Son, London. Price 4/-

The 1911 edition of this book is fully up to the standard of its predecessors as a valuable book of reference for architects, surveyors, and builders. During the last year there has been very little change in the building trade, and only slight variations have taken place in the price of building materials. The prices in the various tables have been carefully corrected to accord with these variations. A list of London district surveyors is given, with the revised boundaries recently made by the L.C.C. In the appendices will be found tables of wages, weights, areas, stamp duties, as well as legal notes and memoranda, including recent important judicial decisions and Parliamentary enactments. There is also a copy of the Workman's Compensation Act, 1906, and of the London Building Act, 1894, with the various amendments up to 1908. The concrete and reinforced concrete sections are dealt with very briefly, and we do not see why, in giving the prices for concrete work, it should in nearly every case be taken as composed of ground lime 1 to 6. This is very seldom used now; 1 to 15 Portland cement would be as strong and much cheaper. We think this section wants revising and bringing up to date. The book, with this one exception, is a very useful one, and is destined to keep up its reputation as a standard work of its kind.

Biggar's Contracting World Directory, 1911.

Published by Odhams, Ltd., Long Acre, W.C. Price 10/6.

The 1911 edition of this directory has just been published. The present issue has been considerably enlarged, and includes several new features. A useful list of the various contractors, not only in England, but also in America, France, and Japan, is given, as well as a guide to where contractors' plant and material may be obtained. The reinforced concrete contractors in England appear in the directory, but we find there are several omissions from these. The book contains all the district, county, city, and borough engineers, as also the waterworks, harbour, and railway engineers. A compendium of the public works under construction at the present time is also included.

Spon's Architects' and Builders' Pocket Book and Diary.

Published by E. and F. Spon, Ltd., Haymarket, S.W.
Prices Section, 2/6; Memoranda Section, 2/6.

We have just received a copy of Spon's Architects' and Builders' Pocket Price Book and Diary, and Pocket Book Memoranda Section. In previous years it has been published as one book only, but is now divided into two parts, making it very much more convenient as a Pocket Reference book.

To the Price Section has been added a diary, and the tables of prices are carefully revised for 1911, although very little alteration has taken place in the building trade.

The Memoranda Section is carefully cross referenced, and many useful notes on various matters have been added. The books will be found most useful to architects and to those engaged in the building trades.

ENQUIRY COLUMN.

The name and address of enquirers must always be given, not necessarily for publication.

The advice given in reply to enquiries is a matter of personal opinion, and although contributed in most cases by experts with special knowledge of the matter in question, it must not be considered in the same light as if obtained from a Consulting Engineer, Architect, or Solicitor, who should always be referred to in important cases, as our columns are not intended to do away with the services of the professional experts on constructional or legal matters.

Replies will be sent by post if the enquiries are marked "Answers by Post" on the outside. All other enquiries will be replied to in this column.—ED.

GRAIN SILOS.

W. H. (Auckland): Could you give me any information for making a reinforced concrete circular silo for ensilage? Size of silo, 24 ft. high by 10 ft. or 12 ft. diameter. I propose putting the silo in the ground about 10 ft. The subsoil is clay.

Reply.—Unless there is some special reason for doing so, there does not appear to be any economy in sinking the silo 10 ft. into the ground, as any saving which may be effected in the reinforcement of the lower portion by allowing the ground pressure to assist in resisting the pressure of the grain inside the bin will be more than counterbalanced by the cost of the excavation.

The main reinforcement should, of course, be circumferential, and in a silo of this size should consist of single rings of bars, or of a spiral, the consecutive rings being spaced at a distance not more than, say, twice the thickness of the concrete. Separate rings are probably preferable to a spiral.

The reinforcement should be placed in the centre of the concrete, and special care should be taken to ensure the portions of concrete on either side of the layer of reinforcement being thoroughly united, so that no plane of cleavage is formed. It is also essential that the ends of the bars forming the rings should be thoroughly tied together by allowing an ample lap, so as to assure transmission of stress.

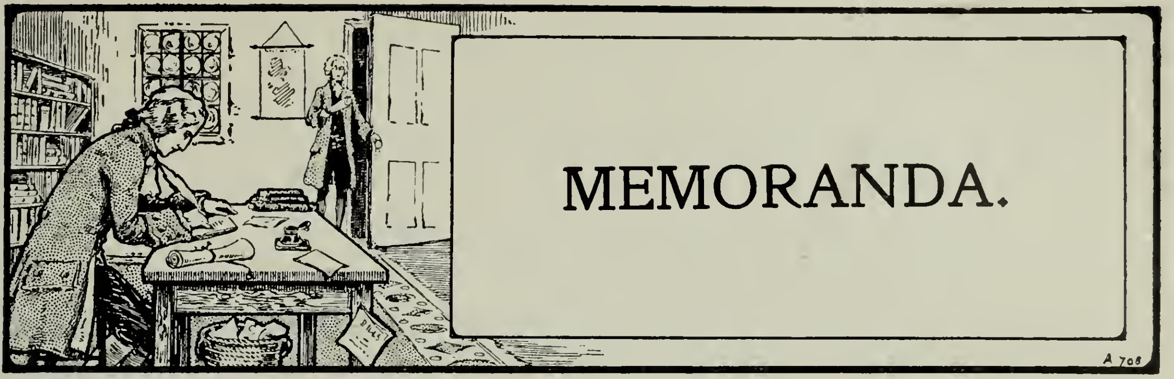
With regard to the calculation of the necessary amount of circumferential reinforcement, Airy's formula is the most generally accepted. This is fully set forth in the Proceedings of the Institution of Civil Engineers, Vol. CXXXI, 1897, or a full discussion of the whole question can be found in "Walls, Bins and Grain Elevators," by Ketchum.

CONCRETE SEWER PIPES.

W. M. D. (Vancouver): We have trouble here with a young engineer who claims that the acids in sewage often exist in such quantities as to injure the concrete pipes. Could you give me any particulars about this?

Reply.—An ordinary amount of acids in sewerage has no bad effect, which you will see borne out by various articles and papers which have appeared from time to time in our journal, and we would refer you particularly to a paper on "The Effects of Sewage and Sewage Gases on Portland Cement Concrete," which appeared in our May, 1910, number; also to an article entitled "Reinforced Concrete Sewer Construction in San Francisco," in July, 1910, and one on "Concrete Tubes as Sewer Pipes," in December, 1909.

This is further proved by the fact that there is a reinforced concrete rising main in the Paris sewerage system, which has been in use for 17 years now, and which was recently examined by a deputation of members from the Concrete Institute. Part of the pipe had to be removed to put in a junction, and it was found on inspection that the steel was not corroded, and that the concrete was in excellent condition. There are numerous plain concrete pipes that have been used for many years for sewers, and no trouble has been experienced.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Reinforced Concrete Sleepers on the London & North Western Railway.—About a quarter of a mile of the London & North Western Railway Company's " up " line immediately north of Pinner Station has been laid with sleepers formed of reinforced concrete. These sleepers are placed somewhat closer together than those made of timber, and, except where the chairs are placed, they are of smaller section. It is understood that if the experiment shows satisfactory results, the use of concrete for the purpose will be extended. The company have already had steel sleepers under trial, but the experience gained with them was not encouraging, as it was found that they tended to make the track far more noisy when under traffic.

Belfast Sewage Disposal.—With a view to providing employment and expediting necessary works in connection with the purification of sewage, the Belfast Town Council have authorised the construction of a reinforced concrete channel between the sedimentation tanks at an estimated cost of £1,010.

Reinforced Concrete Bridge at Rainham.—The Essex County Highways Committee have passed plans for the erection of a new bridge on the borders of Rainham and Wennington to take the place of the old South Hall Bridge. The new bridge, which is to be constructed in reinforced concrete, will be 27 ft. wide, and will cost about £750.

Bridge at Ickenham.—The Uxbridge R.D.C. have resolved to proceed with the reconstruction in reinforced concrete of the bridge over the River Pinn.

Convention of the American National Association of Cement Users.—The seventh annual convention of this Association was held in New York in December last. The attendance was large, a number of delegates from foreign concrete societies were present, and visits were paid to different interesting concrete works in progress in New York and its neighbourhood. At the business meeting, held on December 12th, Mr. Richard L. Humphrey was re-elected President of the Association. The papers presented were of a high character.

At the conclusion of the Convention a resolution was adopted that the work of the Association in encouraging the construction of fireproof buildings and adopting proper safeguards to protect property and life from fire hazards be called to the attention of the officials of building departments with a view to the adoption by them of the standard specifications of the Association applicable to their particular work.

A report of the committee on concrete and reinforced concrete was presented. The committee pointed out, as it did last year, the advisability of having tests of full-size panels, and stated that it was desirous of co-operating with engineers, architects, and building departments in making such tests on completed structures.

Association of American Portland Cement Manufacturers.—This Association held its annual meeting in New York from December 12th to 14th, when a number of papers and reports were read, among these being " The Unification of Government

Specifications for Cement," by J. E. Howard; "The Use and Results of the Air Separator as Applied to Cement," by Oscar Pfeiffer; and a "Summary of the Proceedings of the German Portland Cement Manufacturers."

Canadian Cement and Concrete Association.—The convention and cement show of this Association, which it was originally intended to hold in January, will take place in the St. Lawrence Arena, Toronto, from March 6th to March 11th next. A number of interesting papers will be read, and a large and influential attendance is anticipated. The Secretary of the Association is now Mr. William Snaith, and the offices are at 57 Adelaide Street, East Toronto.

Institution of Civil Engineers: Students' Meeting.—At a students' meeting held at the Institution of Civil Engineers in December last, Mr. C. S. Meik, M.Inst.C.E., in the chair, Mr. R. N. Mirza read a paper on "Calculation of the Most Economical Ratio of Steel in Reinforced Concrete Beams and Slabs." The author, basing his calculations upon the usual stresses of 600 and 17,000 lb. per sq. in. in the concrete and steel respectively, evolved a formula from which could be estimated the total cost of a structure, having given the ratio of cost of concrete and steel per unit. The paper was supplemented by curves drawn to show the varying cost of the structure with different percentages of reinforcement, and the most economical ratio for practical use. The paper was followed by a good discussion, the chairman in his remarks drawing attention to the greater reliability of steel compared with concrete and the proportionately higher factor of safety required in the latter material. The following students spoke: Messrs. E. F. Hunt, G. F. Walton, G. A. Clark, H. J. Gourley, and A. J. Hart.

The National Gallery Extensions.—The extension to the National Gallery, part of which we described at length in our issue of September, 1909, is about to be opened to the public. The extension consists of three rooms on the ground floor, and four galleries and a circular dome gallery on the first floor. The roof consists in each case of arched girders in reinforced concrete, finished with fibrous plaster and panelled with wired glass. Reinforced concrete on the Kalin system was used to secure fire resistance. All the older galleries are to be reconstructed in a similar way.

Recovering Cement from "Empty" Cement Sacks.—An interesting investigation has recently been conducted by the Aberthaw Construction Co., of Boston, Mass., relative to the economy of treating empty cement sacks to recover cement adhering to them before bundling for return shipment. Instructions were sent to a number of jobs to have the man who was bundling the bags stretch each one over two sticks, mouth down, and then beat well. The cement was collected in a box. A careful account was kept of the number of bags shaken, the amount of cement saved, and the amount of the man's wages. Strength tests were made on the recovered strength, as it was probable that dirt or other foreign substances might be mixed with same. The total number of bags reported was 7,598; the amount of cement saved 4,130 lb. The cost of shaking, bundling, and tagging the above bags was $22.44 (£4 13s. 8d.), or about one-third more than the average cost of bundling and tagging without shaking. Hence the net cost of the cement saved was $7.48 (£1 11s.).

Comparative tests were made of the tensile strength of the shakings and of fresh cement from the same lots. An average of these tests showed a loss of 59 per cent. in strength after a 24-hr. set, but a loss of only 35½ per cent. after a 7-day set. On the basis of this last figure, the 4,130 lb. of shaken cement is equivalent to 2,664 lb. of fresh cement. At 380 lb. to the barrel there was an equivalent of seven barrels of fresh cement recovered. The average price paid for cement on these jobs was $1.41, so the value of the recovered cement was $9.87 (£2 1s. 1d.)

There is a further consideration, however, and that is the saving in freight on the cement shaken from the bags. The average freight paid for returning the bags from these jobs was 24 cents per 100 lb., which would amount to $10.01 on 4,130 lb. The total net amount saved is consequently $13.30 (£2 15s. 6d.).

Concrete Telegraph Poles at Niagara Falls.—Concrete telegraph poles 17½ ft. high above the roof have been erected on one of the buildings of the United States

Aluminium Co., at Niagara Falls. They are 16 in. square at the base, 10 in. square at the top, and are reinforced with eight $\frac{1}{2}$-in. bars bound with $\frac{1}{4}$-in. hoops 18 in. centre to centre. At a height of 5$\frac{1}{2}$ ft. above the roof and 4 ft. above the parapet they are braced by three struts, two parallel to the building wall and one backward all of them anchored to the roof by four $\frac{3}{8}$-in. bolts 2 ft. long. The struts are 12 in. square reinforced with four $\frac{1}{2}$-in. bars and $\frac{5}{16}$-in. hoops 18 in. on centres.—*The Engineer.*

A Concrete-Lined Ash-Bin.—It was necessary to provide a fireproof lining for a wooden ash-bin for the National Sugar Refining Co., of New York, as the quenched ashes are delivered to the bin steaming from the boilers, and are often still steaming when delivered to the barges alongside. It was proposed to use steel plates for this purpose, but the designer objected to the use of steel, because in his experience with steel coal-bins the moisture and sulphur, which coal usually contains when stored, had proved very destructive. As there is no way of drying the coal after it is stored, moisture accumulated, especially in the dust in the lower part of the bin. The steel was so badly corroded that in three or four years holes appeared which it was extremely difficult to repair. It was believed that the hot, wet ashes would be even more destructive, and it was finally decided to provide for them a concrete lining about 4 in. thick on all exposed surfaces of the bin.

The inner surfaces of the inclined bottom and vertical walls of the bin were furred with 1-in. wooden strips well nailed and covered with a continuous sheet of expanded metal of rather small mesh thoroughly secured with numerous staples. The concrete, made rather wet in 1 : 2 : 4 proportions of Portland cement, sand, and screenings, was placed on the inclined bottom without forms, and the upper surface was trowelled smooth.

On the vertical walls forms were made of $\frac{7}{8}$-in. yellow pine tongue and groove flooring with the planed side inward. The horizontal boards making the forms were nailed together in panels with outside transverse batten strips projecting a few inches beyond both the upper and lower edges of the board to form cleats engaging the adjacent panels above and below. They were bolted to the walls of the bin by $\frac{3}{4}$-in. bolts passing through the battens about 4 ft. apart. The projecting cleats and the spacing blocks against which the panels were bolted served to maintain them accurately in position, so that when they were stripped the face of the concrete was left very smooth and regular.

The work was done from a suspended inside platform, and the concrete was thoroughly worked by tamping bars.

The bin was designed and built by Mr. W. J. Haskins, 50 Church Street, New York, and the lining is now in excellent condition after having been five years in service.—*Engineering Record.*

Reinforced Concrete at Strasburg Cathedral.—We hear that this famous Cathedral is in a dangerous condition. The report issued by a special commission points out that the pressure on the foundation walls of the tower has been nine times in excess of what the ground should actually sustain, and that unless measures are soon taken to strengthen the same, great damage is likely soon to occur. The main pillar at the north end of the Cathedral also shows great cracks. It is proposed to rebuild a part of the Cathedral with reinforced concrete piles and pillars—reinforced concrete being the only material that, in the opinion of the commission, will save this ancient edifice from complete destruction.

Concrete Coast Defences.—"Recent tests at Sandy Hook of the resisting power of reinforced concrete as a defence against high-powered projectiles confirm the calculations of the penetrating power of the 12-in. gun.

A concrete wall 20 ft. thick, heavily reinforced with steel beams, was pierced by a 12-in. projectile fired at high velocity. The blow delivered was sufficient to penetrate 22 in. of armour-plate, and the reinforced concrete withstood the attacks so well that it will probably be used in the construction of the new coast defence fortifications in the Philippines. A similar attack is to be made with the 14-in. gun."

THE BRITISH STEEL PILING COMPANY

TELEGRAMS;
"GRAMERCY, LONDON."

TELEPHONES
P.O. 1414 CENTRAL.
NAT. 1414 AVENUE.

STEEL SHEET PILING,
PILE DRIVING EQUIPMENT,
COLLAPSIBLE STEEL CENTERING.

CODES,
A.I., A.B.C. 4TH & 5TH EDITIONS
CENTURY, WESTERN UNION,
LIEBERS, IRONSCRAP,
PRIVATE

DOCK HOUSE, BILLITER STREET,
LONDON, E.C.

1st., November. 1910.

Dear Sirs,

May we draw your attention to our specialities, namely - Steel Sheet Piling, Pile Driving Equipments of all kinds, and the Blaw system of Collapsible Steel Centering.

Our "Universal" Joist Steel Sheet Piling is the most practical Piling ever produced, consisting of British Standard Joists in conjunction with an Interlocking member formed of a Joist having flanges turned over, the two being assembled together at the Works and driven as one. It possesses greater strength than any other Piling, is practically watertight, is easily driven and withdrawn, and can be used repeatedly, whilst the Joists have a high salvage value when finished with as Piling for building or other purposes. It is used by the British and Colonial Governments, and the principal Contractors at Home and Abroad; thousands of tons have been already used with great success, whilst the price is moderate.

We make Pile Driving Equipments of all kinds, namely - Direct Acting Steam Pile Drivers, Steam, Electric and Petrol driven Friction Winches. Our Plant embodies all the latest improvements, whilst the workmanship and materials are of the very highest quality.

The Blaw system of Collapsible Steel Centering is for the construction of Concrete, Brick or Reinforced Concrete sewers, conduits, culverts of all kinds; it is made in all sizes from 1ft. to 40 ft. diameter. It effects an enormous saving in this class of work, as no repairs or renewals are required; the Centers can be handled in much less time than timber by unskilled labour, whilst a much finer finish to the concrete is obtained. For use in the United Kingdom we let them on lease at a cost absolutely under that of building timber centers, whilst for Export we sell outright.

May we send you our catalogues, you will find them interesting even if you have no requirements in this direction at the moment.

Yours faithfully,
THE BRITISH STEEL PILING CO.,

Manager.

dict. H.T.G.-T.C.

CORRESPONDENCE.

12 King's Parade, Cambridge,
January 11*th*, 1911.

Dear Sir,—Will you be so kind as to extend the hospitality of your correspondence column to me for a few remarks on M. Maurice Béhar's article in your issue for January? Then let me go on, for I fear I cannot agree with his conclusions.

M. Béhar says: "If we consider *Fig.* 3 . . . we have two efforts starting from the point A. . . . The resultant force acting in a downward direction has a tendency to shear the concrete, so that the bars, which are placed in a normal direction to this force, have a tendency to be sheared through." Now I maintain that one cannot treat the subject in this way. If there be a shear force from right to left, as shown in *Fig.* 3 of the article, there is an equal shear force perpendicular thereto, which seems to have been entirely neglected. Would M. Béhar take the resultant of these and say it acts vertically? Then there is an equal horizontal shearing force, and we arrive whence we set out. We must deal with principal stresses, and on the neutral axis these are, in fact, inclined at 45° to the axis, for here the stress due to bending is zero. At any point in the beam we have two principal stresses, P and Q (P > Q), which are *normal* and not tangential actions. Now the ultimate resistance of concrete in shear is greater than its ultimate resistance in tension. Hence, as soon as the greatest principal stress, P, reaches the ultimate tensile strength of the concrete, the material will develop a split at right angles to the line of action of P, and it has been shown that this is what happens. The concrete yields by tension. The direction of P is approximately the direction of the reinforcing bars in the neighbourhood of the supports, and these are in *tension*.

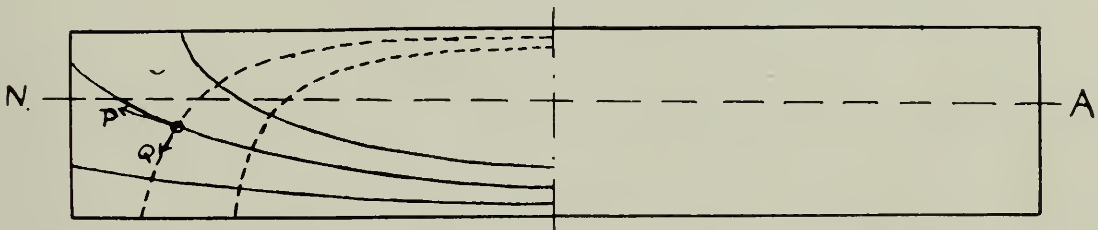


Diagram showing direction of principal stresses for half a beam. The full curves show the greater and the dotted the lesser principal stresses.

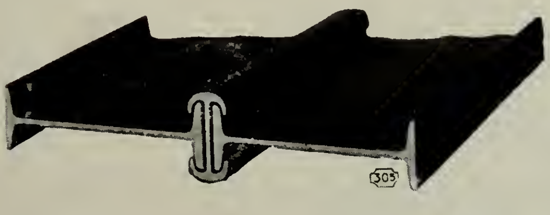
Yours faithfully, John Case, B.A.

The Editor, Concrete and Constructional Engineering.

TRADE NOTICES, CATALOGUES, ETC.

The British Steel Piling Co., of Dock House, Billiter Street, E.C., have sent us a copy of their latest pamphlet dealing with their "Universal Joist Steel Sheet Piling." Their other manufactures will be dealt with separately in different catalogues at a later date.

One of the special advantages of the Company's standard joist, which has a flange of 5 in. wide, is that by using a series of these joists any desired space may be made up. All the joists can be used with the same interlocking clutch, so that the piling can be strengthened, if necessary, at any particular spot by putting in at that point joists with the flanges closer together, and consequently greater lateral strength can be obtained. Although each pile consists of two members—a joist and a clutch—they are driven as one, the clutch being run on the joist before driving.



Section of Universal Joist Steel Sheet Piling.

Full instructions are given in the pamphlet for driving and withdrawing the piles, as well as sizes and weights of the various joists; particulars of fishplating (which is sometimes necessary when the piles are driven in short lengths); corners which are supplied bent to any angle, and junctions.

There are good illustrations of different examples of recent applications of the

Company's piling, two showing it in use at the new naval base at Rosyth, and one showing the piling in use for coast protection work near Walmer, and it has also been employed for similar work by the War Department for the repairs to Haslar Wall at Portsmouth.

The pamphlet is got up very artistically, and is well printed and illustrated. It has also, we understand, been published in French and Spanish.

Messrs. Drew-Bear Perks & Co., Ltd., have recently issued a booklet entitled "Steel Construction," which gives in a very neat and handy form a list of tables and formulæ comprising the properties, working stresses, safe loads, etc., on different sections of steel joists, girders, columns, and stanchions, and which should be of use to architects, engineers, and all those connected with steel construction in any form. Most of the load tables have been calculated in accordance with the requirements of the London Building Act Amendment, 1909.

The booklet contains numerous reproductions from photographs of contracts carried out by this firm, including the steelwork for a large number of theatres; also for race-stands, bridges, warehouses, etc., which give an idea of the variety of the work undertaken by Messrs. Drew-Bear Perks.

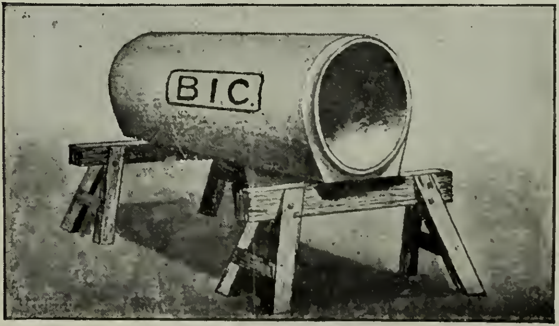
Altogether it is a very convenient little reference book on steel construction, and the sheets of memoranda as to weights and measurements should also be useful.

The British Rubber Manufacturing Co. have sent us particulars of their "Slipknot" belt and rope preservative, which should be very useful to all power users, for, as the name implies, it prevents slipping of belts and ropes, and therefore increases the power very materially. It is non-inflammable, and penetrates to the fibre of the belt without stickiness. The manufacturers claim that "Slipknot," which is made of a solution of rubber mixed with certain preservative compounds, gives the greatest possible adhesive power, permanently cures belt slipping, and greatly improves the condition of belts and ropes by rendering them elastic, pliable, and tenacious. It also protects all metal ropes from oxidation, rust, and corrosion.

As the quality of this preparation cannot well be explained in print, the manufacturers are prepared to send samples on approval to anyone desiring same. The address of the Company is 8 & 9 South Parade, Manchester.

"BIC" **BRITISH** "BIC"
IMPROVED CONSTRUCTION CO., LD.
TELEPHONE: 4067 VICTORIA. TELEGRAMS: "BICONCRETE, LONDON."
47 VICTORIA STREET, WESTMINSTER.

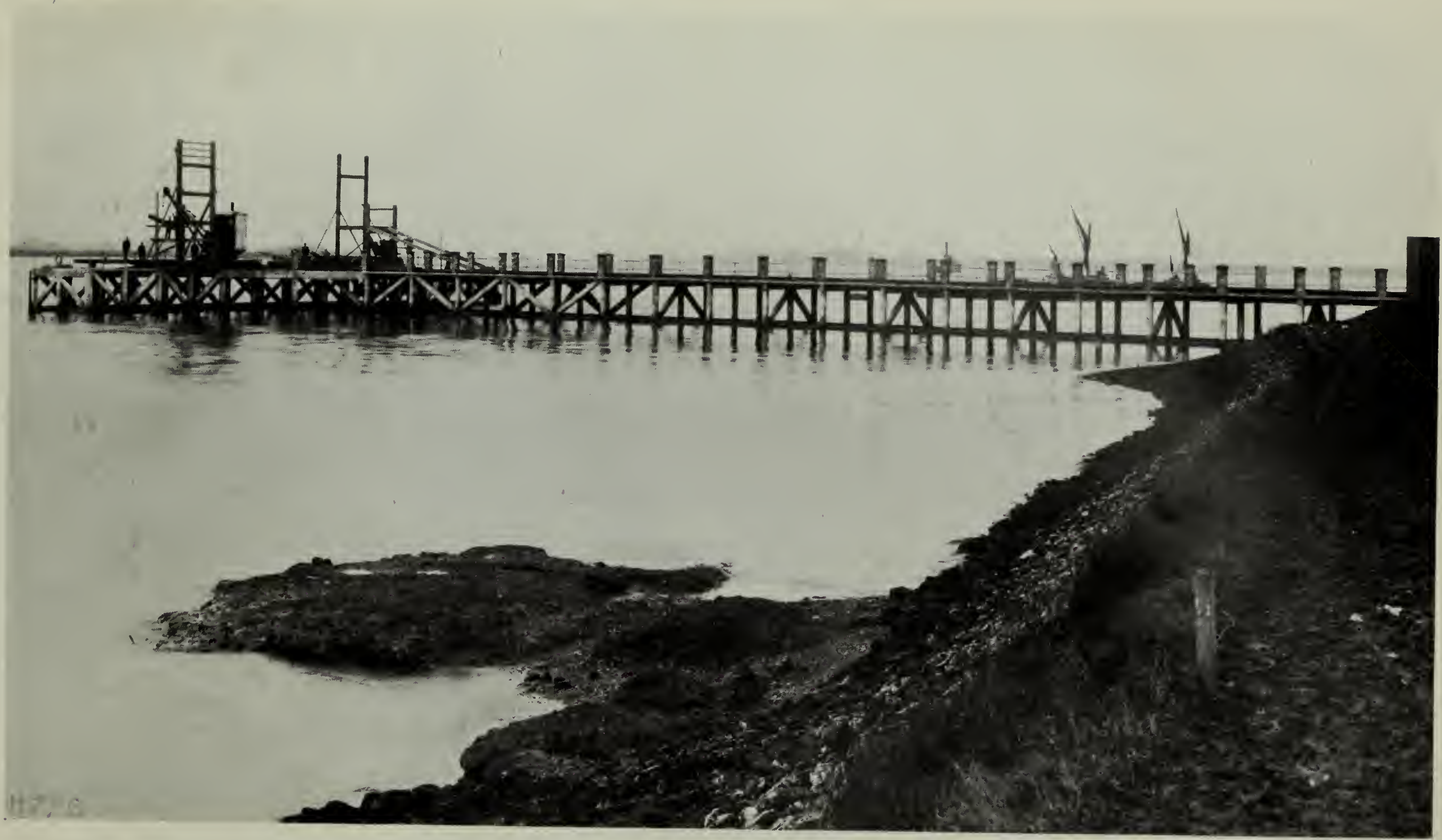
Flat-based Concrete Pipes
Three feet long to Nine feet long.



Breeze Partitions
Reinforced Sleepers
Telegraph Poles

Porous Pipes
Concrete Beams
Hollow Floors

SPECIALITY:—INVENTORS' DESIGNS CARRIED OUT TO ORDER.



Frontispiece
(Opp. Contents).

View of Jetty at high tide.

Reinforced Concrete Jetty, Dagenham Dock, Essex.

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume VI. No. 3. LONDON, MARCH, 1911.

EDITORIAL NOTES.

THE PROPOSED LONDON COUNTY COUNCIL REGULATIONS FOR REINFORCED CONCRETE.

OUR comments on the fact that the views of the Royal Institute of British Architects could not be considered friendly to the London County Council have been freely commented upon. They were occasioned by the Conference called by that body to consider the London County Council's Draft Regulations on Reinforced Concrete.

Whilst a number of our correspondents agree with us, several consider our strictures uncalled for.

It is not our intention to enter into any controversy on such a question, nor do we hold a brief for the Superintending Architect. But for those who do not agree with our view, we would recall the antagonism of the leading members of the Institute and their friends in the Conferences of 1909, when certain Building Act Amendments were under consideration, and we would also point to their evidence before the House of Commons Committee which considered those amendments. Mr. Searles-Wood, a member of the Institute, was, we believe, the only member of the current Conference on the regulations who assisted Mr. Riley by giving evidence in the interests of the London County Council. Messrs. Hall and Dunn, of the Institute, were actively engaged in combating the Superintending Architect, and Sir A. Stenning, of the Surveyors' Institution, assisted them. The Institute of Builders and the London Master Builders' Association also opposed quite energetically.

Now the current Conference on the Regulations on Reinforced Concrete comprises the representatives of the Royal Institute of British Architects, the Surveyors' Institution, the London Master Builders' Association, and the Institute of Builders, together twelve representatives (including Mr. Hall as Chairman), whilst the other two bodies sending delegates are the Concrete Institute, with two deputies, and the District Surveyors' Association, with three—the first-named institute, we should add, also having opposed the London County Council in 1909. Thus, on the face of it, it will be seen that, but for the District Surveyors, the current Conference could scarcely be termed one friendly to the London County Council, but much less so if the history and details of the 1909 controversy be remembered.

At conferences such as the current one, each delegate must naturally act loyally on behalf of the society he represents ; but, nevertheless, it is to be hoped that this will not be done blindly. Of course, the position of the members is somewhat anomalous, for whilst each delegate specifically represents a special body, ten out of the eighteen members are Fellows or Associates of the Royal Institute of British Architects, and nearly half are members of the Concrete Institute.

We hold—as we have indicated before—that this is a case of primary interest to the Concrete Institute, and that the latter body is strong enough and sufficiently representative to act entirely on its own. The Concrete Institute should assist the County Council in every way to improve the proposed regulations, and not take part—either actively or latently—in any general opposition to the principles laid down in the London County Council draft.

Such general opposition may be conducted diplomatically, and the resolutions arrived at framed in courteous language ; but it may be none the less of an aggressive, not to say virulent, character in reality. We fail to see what advantage those concerned in the design and in the practice of reinforced concrete will gain by co-operation with those who are opposed in principle to the general measure which gave the London County Council the necessary powers to frame regulations which, no matter if framed somewhat more strictly than the opponents desire to see, must in any case in time materially facilitate the execution of sound reinforced concrete work, and obtain from the man in the street that general feeling of confidence for the new material which is still somewhat lacking.

Below we give the constitution of the Conference, and we indicate the Fellows and Associates of the Royal Institute of British Architects, the Fellows of the Surveyors' Institution, and the Members of the Concrete Institute with the usual initials.

Royal Institute of British Architects.

Edwin T. Hall, V.P.R.I.B.A., Chairman.
Wm. Dunn, F.R.I.B.A., M.C.I.
H. D. Searles-Wood, F.R.I.B.A., M.C.I., Hon. Sec.

Institute of Builders.

F. Higgs. G. B. Godson.

London Master Builders' Association.

Thomas Holloway. William King, M.C.I.
Frank May, J.P., M.C.I.

Concrete Institute.

Charles Marsh, M.Inst.C.E., M.C.I. T. B. Shore, M.C.I.

Surveyors' Institution.

Sir Alex. Stenning, F.R.I.B.A., Past President Surveyors' Inst.
Howard Chatfeild Clarke, F.R.I.B.A., F.S.I.
E. B. I'Anson, F.R.I.B.A., F.S.I.
Percival Currey, F.R.I.B.A., F.S.I.
Edward Dru Drury, F.R.I.B.A., F.S.I., M.C.I.

District Surveyors' Association.

Bernard Dicksee, F.R.I.B.A.
Wilfrid Hardcastle, F.R.I.B.A., M.C.I. F. A. Perkins.

As to the views of the Conference, we understand that it was pointed out that the Report of the Joint Committee on Reinforced Concrete issued by the

Royal Institute of British Architects required revision owing to the progress of knowledge and experience, and that the Reinforced Concrete Committee is again sitting to consider what alterations are desirable.

The Conference, it is stated, was of opinion that it would be best still to use the methods of calculation given in the Report of the Royal Institute of British Architects on Reinforced Concrete, or subsequent reports made by the same body, and not to introduce formulæ into regulations, which would tend to stereotype these particular formulæ and hinder the development of new modes of construction.

These views, couched in diplomatic language, mean that the Conference does not like the draft regulations, and wish to see something else provided, but in actuality they mean that certain members of the Conference are opposing the draft regulations by all the means at their disposal.

As we have indicated before, we hold that, broadly speaking, the proposed regulations, as originally drafted by the London County Council, would be workable, subject to the correction of some obvious errors, the strengthening of the clauses on fire protection, and a suitable provision for coke breeze. We trust the Superintending Architect will maintain the position originally taken up, and that he will be able to convince the Local Government Board, which has to approve of the regulations, that his views are both practical and politic.

REINFORCED CONCRETE SPECIALISTS AND ARCHITECTS.

THE paper, which was read recently before the Concrete Institute on the subject of "Competitive Designs and Tenders for Reinforced Concrete Work," a summary of which we publish on page 212, concerns a vexed question. To the firms engaged in the work such matters are regarded more or less in the light of the fortune of war when business is brisk ; yet, for all that, the disadvantages remain, and it is as well to examine the subject in detail to see if a remedy cannot be effected. We suppose those who are specially concerned do not care to speak quite openly and plainly about the matter, and Mr. R. W. Vawdrey, the author of the paper in question, skates very nicely over thin ice ; we propose, however, to break it, and see if we cannot reach the other shore by a different form of transit.

The crux of the matter lies in the question of payment. The specialist firms in the reinforced concrete industry do not care much how it is done as long as they are paid for their work, but they also do occasionally drop a hint that they feel there is another aspect that ought to be studied. Various means of securing the payment for their work have been adopted, and it does not very much matter to these firms, apparently, whether they get it in the form of commission on the cost, as a royalty on a patent, or as profit on the sale of a special article, and it does not apparently matter to them whether they get the commission from the architect, the building owner, or the contractor. Of course, if they are paid on commission or royalty, they may receive payment from any one of the three ; if they get it as a profit on a patented article they get it from the contractor. That they are going to get paid for the work they do stands to reason, and if they have to do a lot of duplicate work by reason of considerable competition on the majority of jobs, then that duplication has to be paid for by a larger commission, royalty, or profit than would be otherwise required.

Now, if all the designs are being prepared with fairly equal knowledge and ability, this competition, by causing unnecessary duplication results in the development of reinforced concrete being retarded. It is an economical form of construction, and the more economical it is made—that is to say, the cheaper it is—the more will it be employed. To-day the knowledge of the subject among specialists is generally sufficient to render the larger part of the competitive designing useless, therefore it is hampering the industry, and it would be to the advantage of the firms if it could be eliminated.

PAYMENT OF THE ARCHITECT OR CONSULTING ENGINEER.

Here comes the difficulty, however, because the payment of the architect or the consulting engineer enters into the problem. They are paid in general, we may say, 5 per cent. commission on the total cost of the work ; when the building owner engages an architect or engineer, he appears to expect that the whole work will be designed in detail by either, and that he will simply have to pay 5 per cent. for all professional assistance. He has, however, been made to understand that there is such a person as a quantity surveyor, whom it would be desirable to employ, because if every builder has to take out his own quantities he will not get such close tendering nor such a close price. While the architect or engineer does not mind telling him that 5 per cent. is not sufficient to cover the cost of taking out the quantities, when it comes to the employment of specialists in connection with various parts of the building he is a little diffident about suggesting to the client that other professional men should be employed. The client has been so far led to think that an architect or consulting engineer ought to know everything about the construction, and should do it for one fixed commission. Well, the solution appears to us to lie in disabusing his mind of the idea, for, until that is done and the specialist designer is placed on an equal footing as an independent professional man, the position of the specialist can never be satisfactory. Clients should be educated to understand that they are engaging an architect to look after their interests in a general way, and in particular to attend to the artistic and decorative side of the structure ; or in the case of the ordinary consulting engineer they should look upon him as their general representative, who devises the general lay-out of the scheme and likewise details the ordinary construction. It should be emphasised that general practitioners have their place in the scale of things, and that modern civilisation and science have so advanced that a man cannot be a general practitioner and a specialist in every branch at the same time.

As to whether 5 per cent. is excessive commission on a large-sized job is quite another matter. We know that on large national buildings our Government have cut down the architect's commission, and that in the United States, due to the country being much bigger and there being many more buildings of great magnitude, there are special firms of architects who retain a staff of specialists and are able to offer to do the whole of the work for an inclusive commission of 5 per cent. Such firms have built up a reputation, and they get plenty of work, so that they are quite satisfied. An architect or engineer who gets a big job can afford to engage specialist designers and pay them out of his commission, but the majority of work in this country is so small, or else the quantity that one man gets is so little, that he cannot afford to give anything away to another professional man ; consequently, he expects to get specialist information in some roundabout way, and the specialists have come up to his expectations.

PAYMENT OF SPECIALIST DESIGNER.

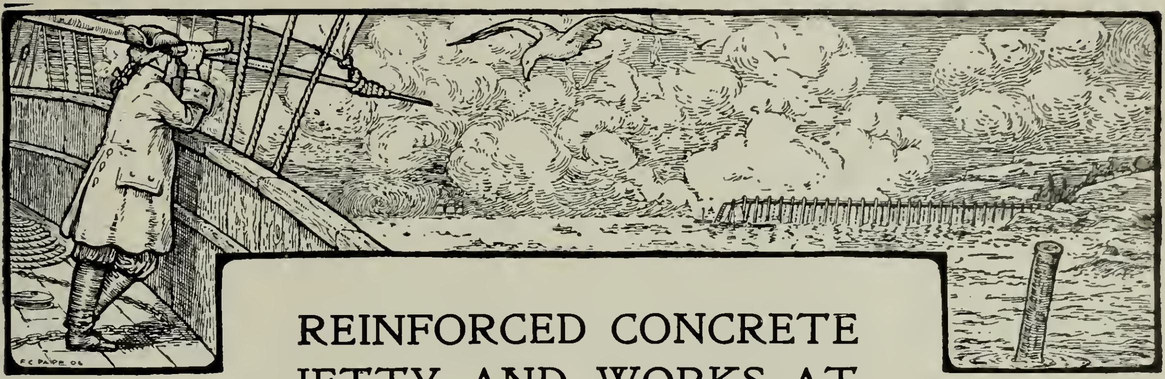
The only way the specialist designer can get paid is to be associated with trade, and, though that may be a very good thing up to a point, it must often be a disadvantage after an industry has begun to settle down. Association with trade certainly leads to the close study of means of securing maximum economy, but it also leads to troubles, which Mr. Vawdrey has pointed out—namely, in the taking of risks and the excessive cutting in both the design and the execution —and, of course, there is the wastage by duplication. Difficulties begin to arise as soon as the architect or engineer requires the designer to be remunerated by way of trade. Firstly, the designer has often to sacrifice efficiency to cheapness. Secondly, if the specialist is a designer and not a contractor, but works with licensed contractors who pay him his commission on the cost of the work, he is inclined to lean unduly towards the contractor, and the architect and engineer must naturally feel a little nervous as to his professional conduct when so closely associated with trade. The result is that there is a disinclination to give jobs to firms of specialist designers who work in this way without competition, because then there would be a risk of their getting excessive commission. This, perhaps, is the reason why some firms say boldly, we do not ask for work to be given us without competition, for we are prepared to give a price and a design and carry out the work completely. On the other hand, there are firms who sell special articles such as patent bars, who think their method of securing remuneration will appeal to professional men more than either of the foregoing methods ; but they, in turn, have to face the difficulty of satisfying the architect that, if he specifies their specialities without obtaining competitive tenders and without an undertaking that these specialities will be supplied at a fixed price, an excessive amount of their specialities will not be worked into the design.

Architects and engineers often call for most elaborate and detailed estimates when a job is in the preliminary stages, instead of putting the firms to that trouble only when everything else is settled. If they needed a rough preliminary idea of the cost, they could get it from one specialist without his going to too much trouble. When competitive tenders are finally asked for, every information regarding the exact conditions should be given and plenty of time should be granted ; one often sees and hears of ridiculous demands being made for a price for a large structure, upon which an architect may have been engaged for months, to be sent by return of post.

One of the speakers in the discussion expressed the opinion that reinforced concrete specialists were specialists mainly for their own specialities. There is, of course, that danger, to which we referred above, of the specialist working in an excessive amount of his own specialities into his designs ; but, on the other hand, where there is competition, it is the object of such firms to cut down the work in every direction to the lowest possible limit, and such specialists have performed a good service, as do all enthusiasts, by emphasising the importance of certain aspects in the problems of reinforced concrete design, and their bias has been advantageous and excusable.

Of course, it is natural that in time the architectural and engineering professions will gain increasing knowledge of the subject generally, and in simple cases work will be designed by the ordinary practitioner using ordinary commercial sections without the aid of a specialist, and in a few years the specialities which have real advantages will become ordinary sections obtainable from any steel manufacturer because the patents will have run out. Doubtless in time the architectural and engineering professions will come to realise that there are very few systems that have any material differences, and that the solutions that would be offered to any problem by most of the competitive specialist designers would differ very little from each other.

Reinforced concrete design is not so simple that in complicated cases the specialist can be done without. The probability is that we shall before long find specialist designers dissociated from trade, and few firms required to design as well as contract for the execution. The abuses will not be so frequent then. But the building owner must be led to realise that the architect is generally not paid sufficient to employ specialists out of his 5 per cent. commission.



REINFORCED CONCRETE JETTY AND WORKS AT DAGENHAM DOCK.

The following account of the Reinforced Concrete at the Thames Ironworks' Jetty at Dagenham Dock, as well as the various concrete block buildings in connection therewith, should be of interest to our readers.—ED.

APART from the nature of the work, considerable general interest attaches to the illustrations and particulars we publish herewith of the jetty which has just been completed for the Thames Ironworks & Shipbuilding Co., Ltd., at Dagenham Dock, Essex, for it will be recollected that after some years the Thames Ironworks Co. obtained the contract for building a battleship for the Royal Navy and H.M.S. "Thunderer" was launched therefrom on February 1st last.

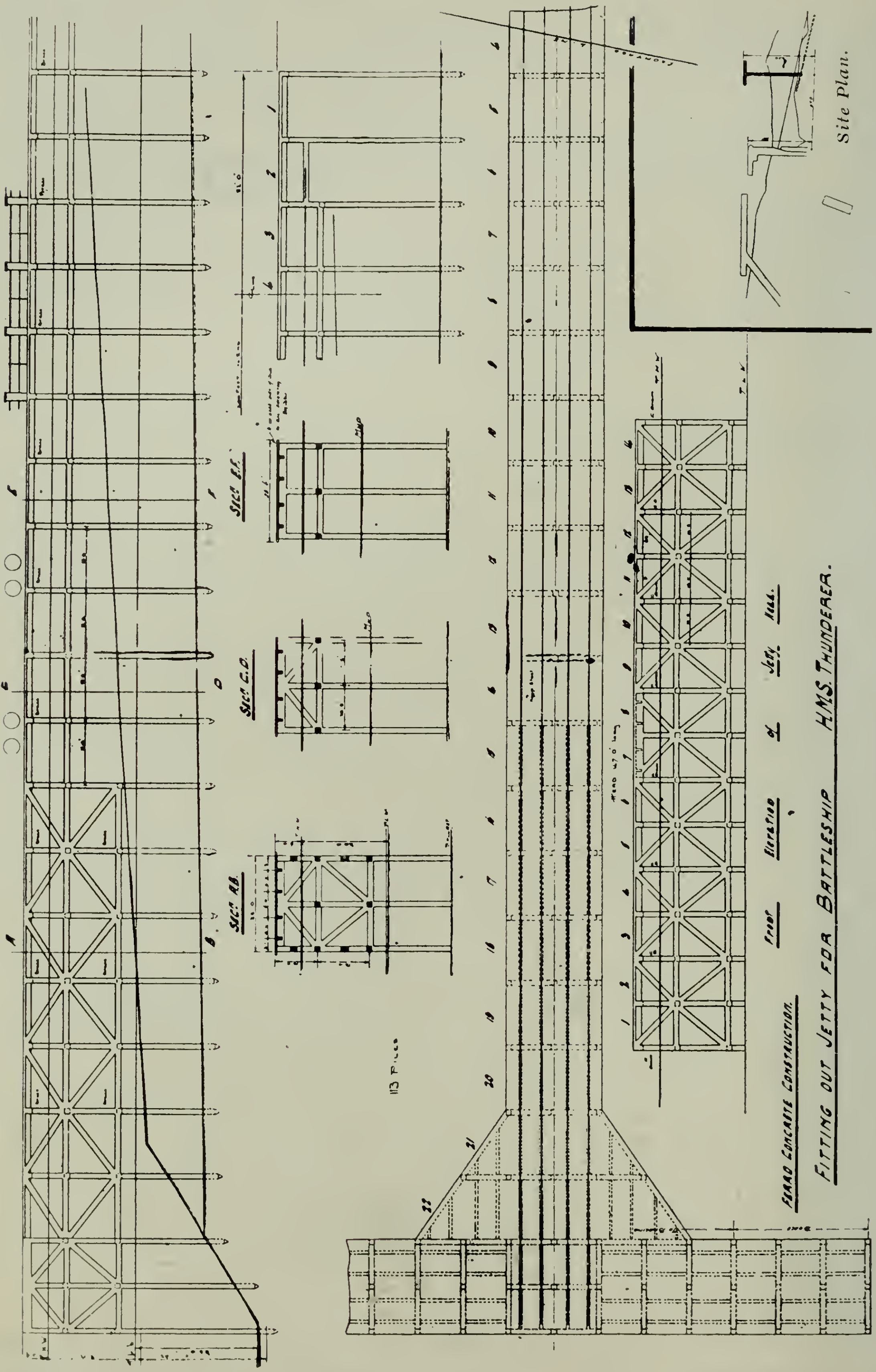
Since this company built battleships, some years before, considerable advance has been made in the size and intricacy of the largest vessels of the Fleet, and consequently it was necessary to execute extensive constructional works to fit the yards for building a super-"Dreadnought."

The part of the work with which we are specially concerned is the jetty that has been constructed to provide accommodation for the hull after it is launched, and while it is being fitted out with its interior construction and machinery.

This jetty is constructed in reinforced concrete throughout, the plan and elevation on page 170 showing the general arrangement. The depth of water at T.L.W. in front of the jetty is 31 ft., and the piles were driven to refusal about 8 ft. deep in a compact bed of ballast which lies below this.

The jetty is designed to carry railway wagons on bogeys weighing 30 tons with loads of 30 tons of armour plate in each, so that the wagons were assumed to weigh as much as 60 tons each. Owing to the height of the tide, in the view of the jetty shown in our frontispiece the lower bracing is not visible, but the elevation on page 170 shows the points at which the jetty was braced in deep water. The construction of this jetty was very speedy, the pile driving being commenced on March 4th, 1910, and the whole of the work completed by November 19th last.

The whole of the work was executed by Messrs. Samuel Williams & Sons, Ltd., of Dagenham Dock, and was designed by Mr. A. E. Williams, Assoc.M.Inst.C.E., M.I.Mech.E., of that firm, on his patent system of reinforced concrete, the distinctive feature of which is the Williams pile, which is illustrated on page 171.

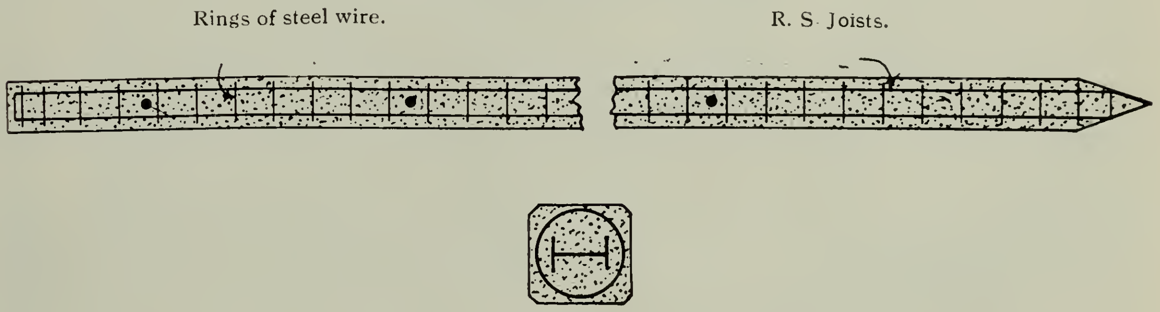

Site Plan.
Sec. E.F.
Sec. C.D.
Sec. A.B.
113 Piles
Elevation of Jetty
Ferro Concrete Construction.
Fitting out Jetty for Battleship H.M.S. Thunderer.

Plan and elevation.
Reinforced Concrete Jetty at Dagenham Dock, Essex.

This pile consists of a rolled steel joist 9¼ in. by 4 in. by 20½ lbs. embedded in concrete so as to give external dimensions to the pile of 14 in. by 14 in. The joist is not fitted with a cast-iron shoe, a piece of the web being merely cut out in the form of a triangle and the flanges bent in until they meet, the corners being cut off to make a point. The other end of the joist is covered by about 2 in. of concrete, and the web is drilled with six holes to enable a fresh piece of joist to be fished on after the pile is driven.

To bond the concrete to the joist, rough rings of $\frac{3}{16}$-in. diameter steel wire, some 11 in. in diameter, are disposed at intervals of about 12 in. about the length of the pile and embedded in the concrete, these being increased in number at the head. Through holes drilled in the web of the joist 2-in. boiler tubes are passed, so as to permit of lifting the pile with the aid of long shackles and pins, and these holes are also used as gauge bolt holes. This arrangement makes it possible to handle the pile four days after it has been made.

The concrete is composed of clean shingle mixed with half its volume of clean, sharp ¾-in. Thames sand, and with 200 lb. of Portland cement to every 9 cu. ft. The concrete is well rammed round the joist.



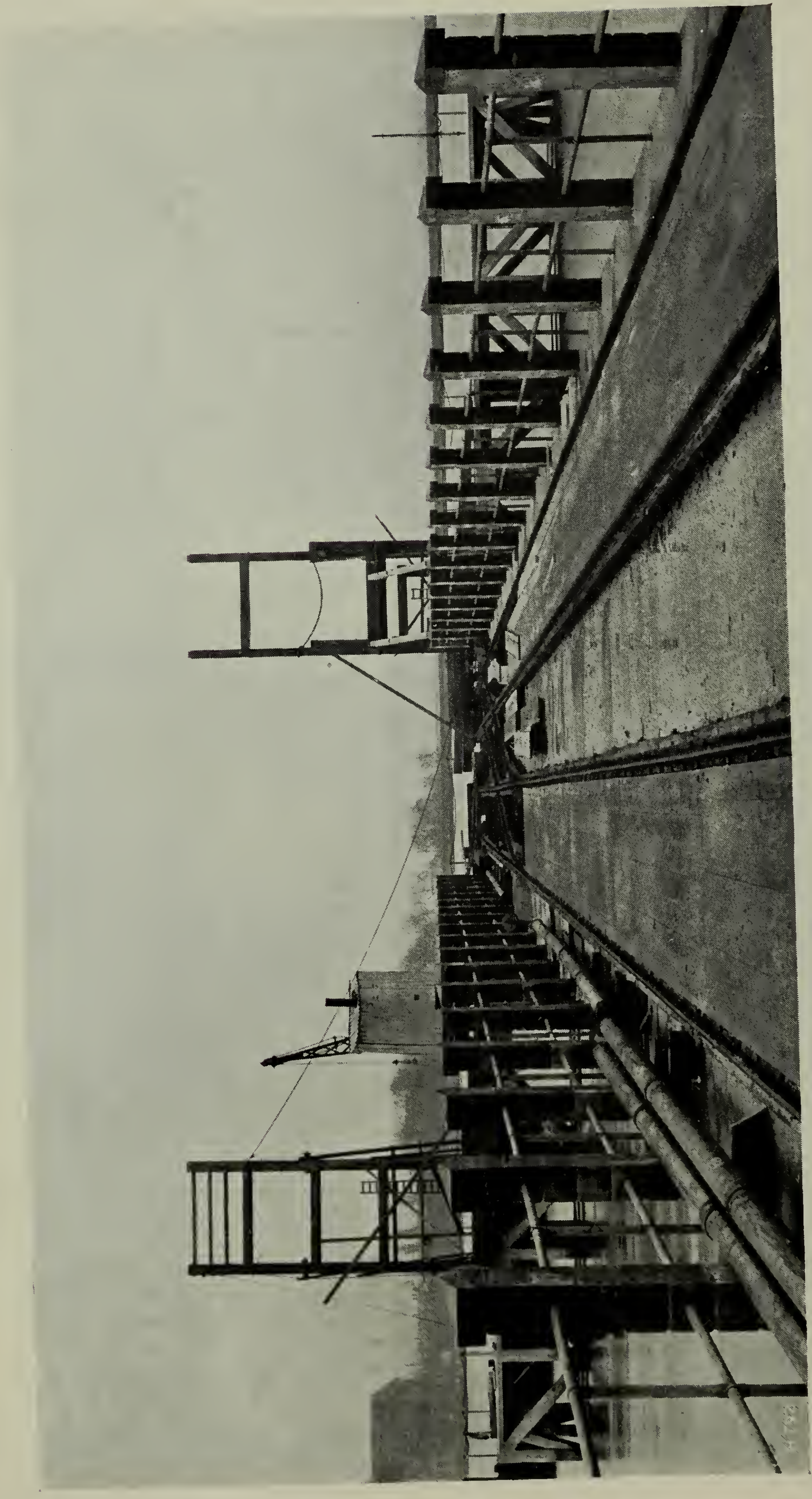
Section and detailed plan.
THE WILLIAMS PILE.

The piles can be taken out of the moulds in four days, and are ready for driving in one or two months, according to the season.

Driving is performed by the usual machines, but the head of the pile is protected by a hard wood dolly, of suitable length to receive the blow of the ram. With the Williams pile, as with reinforced concrete piles generally, it is preferable to use a heavy ram—a 40-cwt. ram falling 6 ft. being generally used by Mr. Williams.

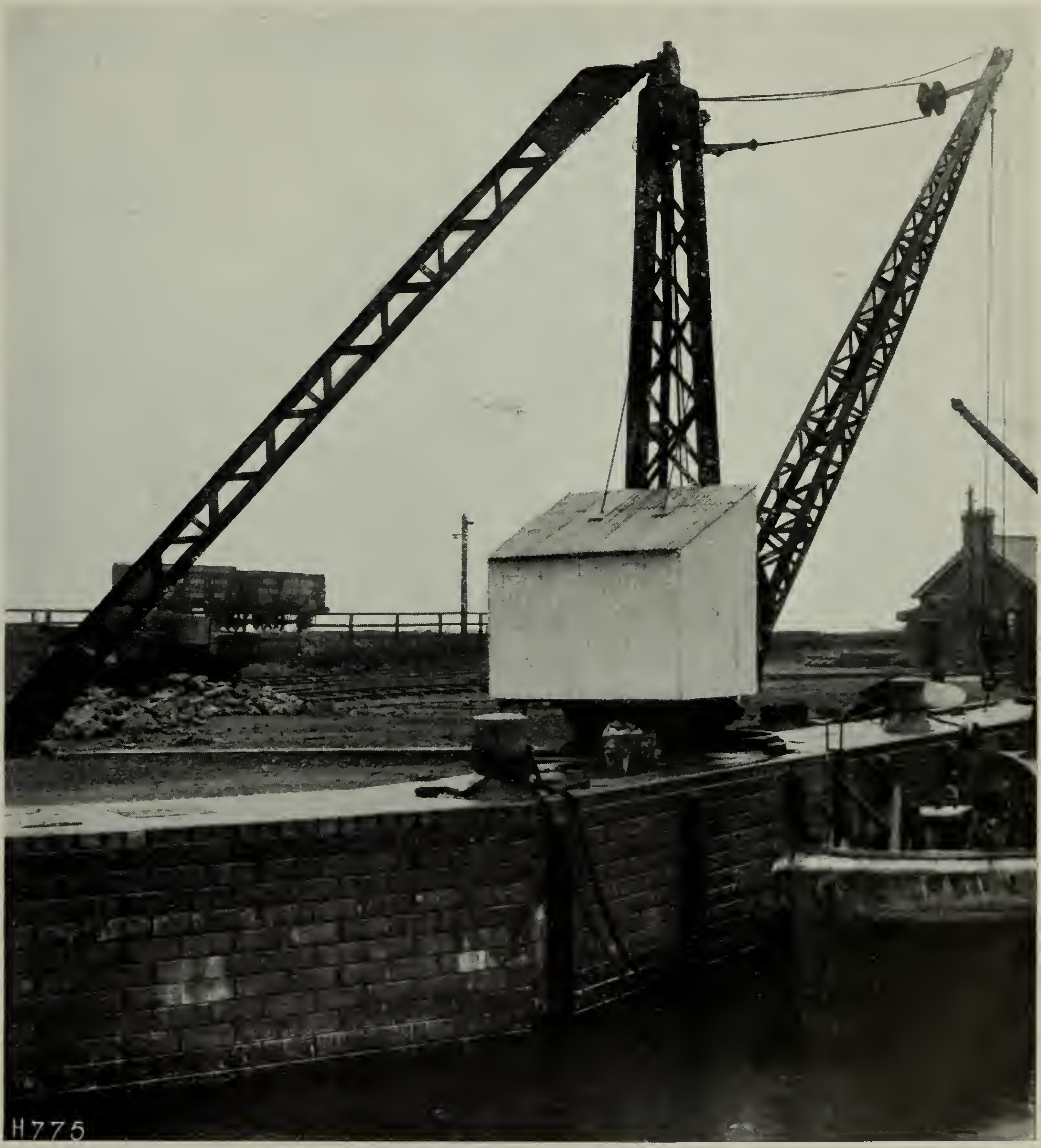
In connection with the fitting out of the "Thunderer" there is a 150-ton crane. Alongside where it is moored is a wharf wall, a section of which is shown on page 173, with a 20-ton electric crane on top. This wall is built of concrete building blocks, which is an interesting application of this form of construction. Concrete building blocks are now being extensively used for various purposes, and, of course, for such a class of work as this they are very durable and cheaper than stone, and, being of small size, can be laid just as easily.

Attention is specially drawn to the bollards for mooring vessels, which are constructed on the concrete block faced wall. These bollards are of reinforced concrete, built with 9 in. by 4¼ in. steel joists through centre, and a few rings of steel wire round them, after the manner of the Williams pile.



Reinforced Concrete Jetty at Dagenham Dock, Essex.

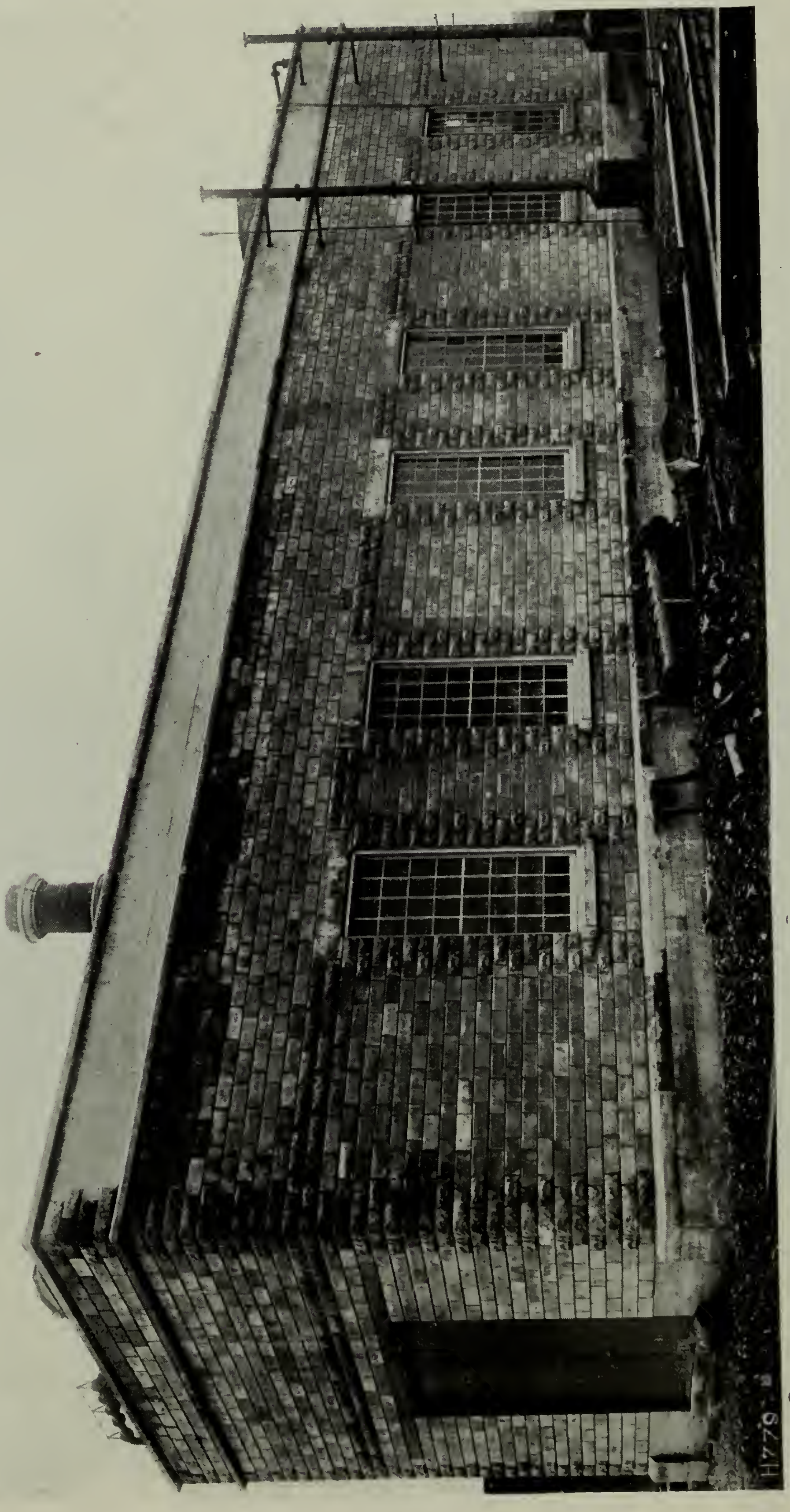
Adjoining this wall is a factory for Johnson's Patent Corrugating Company, measuring 21 ft. long by 90 ft. wide, the roof being built in three spans of 30 ft. This factory being built on unstable soil, it had to be supported on piles, which are of the same pattern as those employed for the jetty. The piles have been built up in the form of sections to carry a reinforced concrete roof, which is only 5 in. thick. No waterproofing material was used, and the roof is perfectly watertight. The walls are of concrete blocks.



20-ton crane on concrete block wall
REINFORCED CONCRETE JETTY AT DAGENHAM DOCK, ESSEX.

There is also an engine house, shown on page 174, for supplying power to the jetty. It consists of concrete blocks with a reinforced concrete roof, and is 106 ft. long by 29 ft. wide and 29 ft. high.

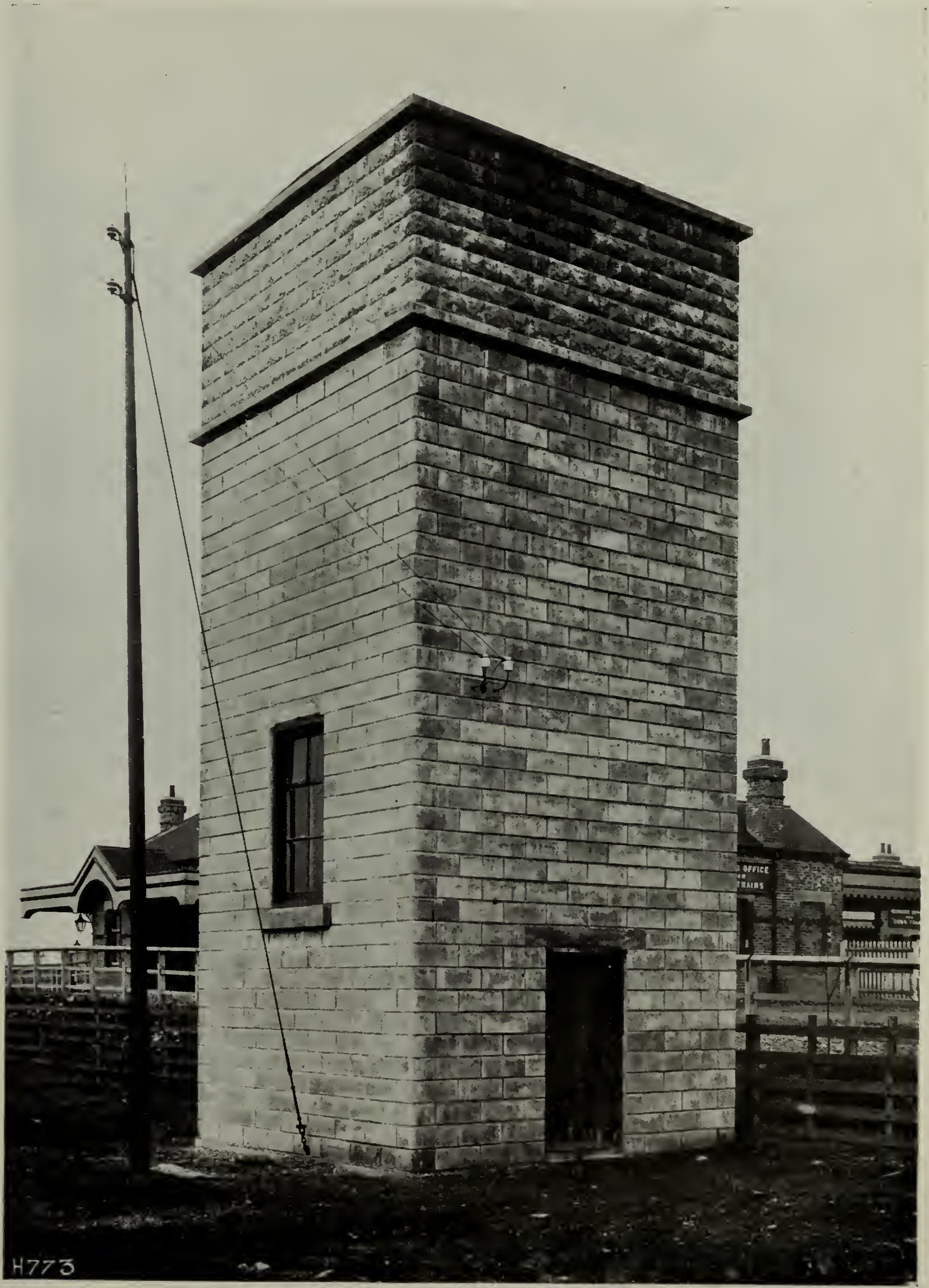
Outside Dagenham Dock station is a water tower, shown on page 175, which was also constructed in connection with the works. The tank, which is 6 in.



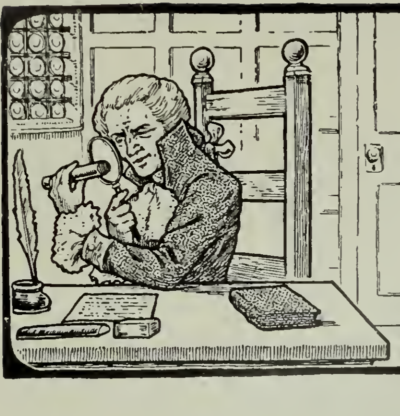
Engine house built of concrete blocks.
Reinforced Concrete Works at Dagenham Dock, Essex.

)

thick, the depth of water being 6 ft., is constructed of reinforced concrete. No waterproofing material was used ; the water tower is built on piles encased with concrete blocks. This tank supplies water to the whole of the works.



Water tower built of concrete blocks.
Reinforced Concrete Works at Dagenham Dock, Essex.



TESTS ON CONCRETE BEAMS AND CUBES.

We have dealt with the Interim Report of the Institution of Civil Engineers' Committee on Reinforced Concrete in our issues of October, November and December, 1910, and are now giving particulars of Tests conducted in Great Britain which were published in that report and which we think merit attention.—ED.

TESTS ON REINFORCED CONCRETE BEAMS.

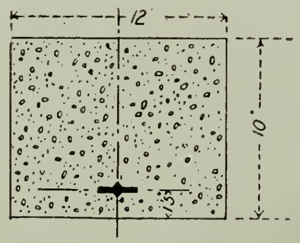
In previous issues we had a series of articles collected from various sources on tests conducted in Great Britain on reinforced concrete, and we are now able to add the results of some further tests that have been carried out subsequently. These we reproduce from the Institution of Civil Engineers' Committee's Interim Report on Reinforced Concrete. They relate to some reinforced concrete beams (Kahn system) which were tested for the South Eastern and Chatham Railway, and the information given below was furnished by Mr. P. C. Tempest, M.Inst.C.E.

Reinforced Concrete Beam.—Concrete composed 4 parts of ordinary sandy ballast to 1 part Portland cement. Made on September 11, 1908, tested December 18, 1908. Beam gradually loaded with short lengths of old rails distributed, resulting thus :

At 6·0 tons	$\frac{3}{8}$ in. deflection ...	Slight vertical crack appeared on side 1 ft. 4 in. from abutment, not right through.
,, 6·6 ,,	$\frac{7}{16}$,, ...	Crack 1 ft. from centre in bottom, about 4 in. up through bottom.
,, 8·0 ,,	$1\frac{1}{4}$,, ...	Crack at centre opening $\frac{1}{16}$ in. full.
,, 10·0 ,,	$2\frac{1}{4}$,, ...	Concrete practically gone, crushing at top and pieces falling out at bottom.

Subsequently loaded to 20·5 tons in endeavour to break beam. This left on for 48 hours without steel bar fracturing, *calculated* stress on steel being then 40 tons/in.^{2}.

An illustration of beam when load was taken off is shown in *Fig.* 1, and *Fig.* 2 shows cross-section of beam.



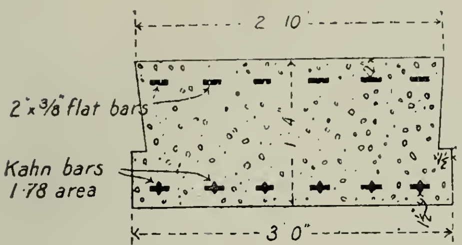
SECTION OF BEAMS ILLUSTRATED IN FIGS. 1 & 3

Area of Kahn Bar 0.78 sq. in.

Fig. 2.

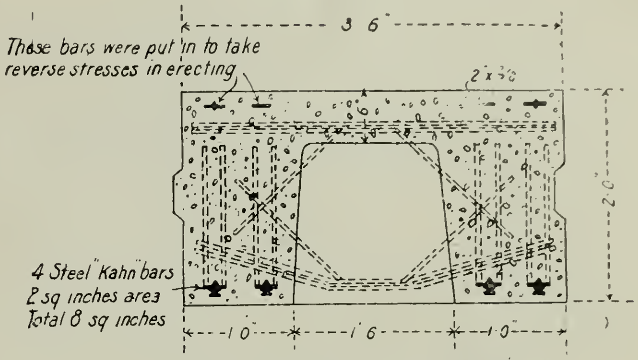
Reinforced Concrete Beam.—Concrete composed 3 parts of broken Kentish rag-stone, 1 part washed, sharp sand and 1 part Portland cement. Made on September 11, 1908, tested December 11, 1908. Tested in first instance with calculated safe load of 6 tons, deflected $\frac{3}{16}$ in., and when load removed, showed permanent set of $\frac{1}{16}$ in. bare, with no sign of cracks ; then reloaded gradually. The second loading at $6\frac{1}{4}$ tons developed several slight cracks in bottom.

At 11 tons deflection ¾ in., and crack at centre opened to $\frac{1}{16}$ in. full, cracks and deflection increased systematically until the full load of 17½ tons reached, when concrete collapsed from compression, steel bar remaining unbroken at *calculated* stress of 32·3 tons/in.². This is illustrated in *Fig.* 3.



CROSS SECTION OF BEAM.

FIG. 5.



CROSS SECTION OF BEAM.

FIG. 8.

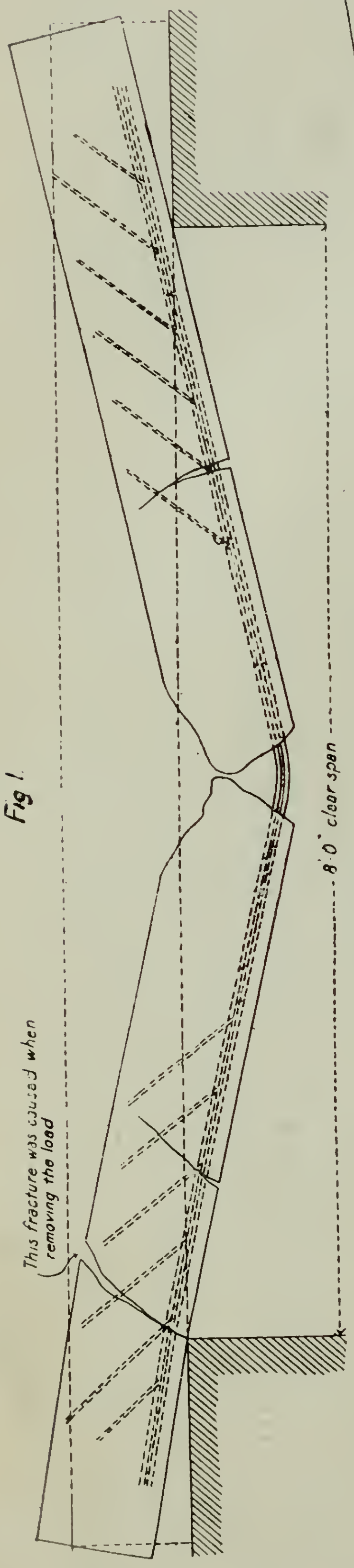
Reinforced Concrete Beam.—Span 24 ft. Concrete composed 1 part Portland cement, 1 part sand and 3 parts broken Kentish ragstone (2 parts fine chippings and 1 part through ¾ in. ring). Made on March 11, 1909, tested May 11, 1909. Cross section of beam and illustration of its appearance after removal of load, given in *Figs.* 5 and 6 respectively. Results of test given in following Table :

Date.	Distributed Load. Tons.	Deflection. Ins.	Remarks.
May 11	18·0	$\frac{7}{16}$	No cracks.
,, 11	24·6	$\frac{9}{16}$	No cracks.
,, 12	36·3	⅞	Started small cracks in bottom below tension (steel) member.
,, 12	45·3	1¼	No appreciable difference in cracks in bottom.
,, 13	—	1⅜	Deflected during night, cracks slightly opening.
,, 13	57·0	1$\frac{7}{16}$	No signs of failure or cracks in top. No appreciable difference in cracks in bottom since yesterday.
,, 13	60·0	1$\frac{9}{16}$	No signs of failure or cracks in top.
,, 13	63·0	1⅞	Centre crack extends right across at bottom 6 ins. up through concrete ; no signs of cracks in top.
,, 13	66·0	2$\frac{9}{16}$	No cracks at top. Crack opening decidedly in bottom. Deflection appears to be increasing without extra loading.
,, 13	67·2	3¼	At 5.10 p.m. Deflected to 3½ ins. at 5.25 p.m. without extra loading.
,, 14	—	—	Beam gone down to 5 ins. total deflection during night. On 13th from 5.30 p.m. dropped ⅛ in. every half-hour to 10 p.m. Cracks in bottom opened and generally extended to within 4 ins. of top.
,, 17	—	—	Since 14th deflection increased to 5½ ins. Still no cracks visible in top ; cracks in bottom remaining normal.
,, 19		5½	No alteration, deflection still 5½ ins.
,, 21	0	6⅝	—
,, 24	76·0	9	Bottom flange of beam set back 1 in. on each inside edge of bearings.
,, 24	79·0	9	Total weight put on, beam being thoroughly crippled ; no recovery whatever when unloaded.

NOTE.—For the total weights on beam at the various periods, 6 tons to be added in each case for the weight of the beam.

Reinforced Beam, Inverted-Trough Section.—Span 29 ft. Concrete composed of same materials as used in last. Section of beam shown in *Fig.* 8, and result of loading in *Fig.* 9.

Made on April 20, tested July 9, 1909, with distributed load of old rails gradually applied. The following Table gives results of test.



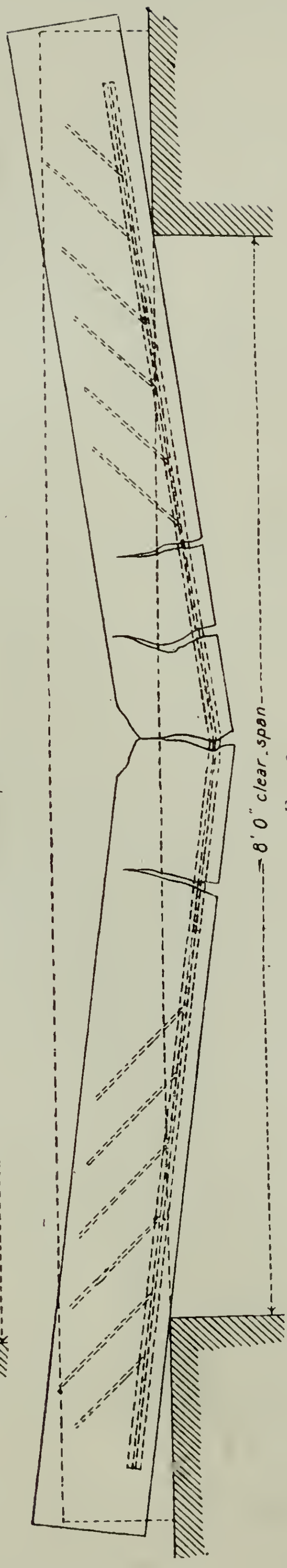


Fig. 3

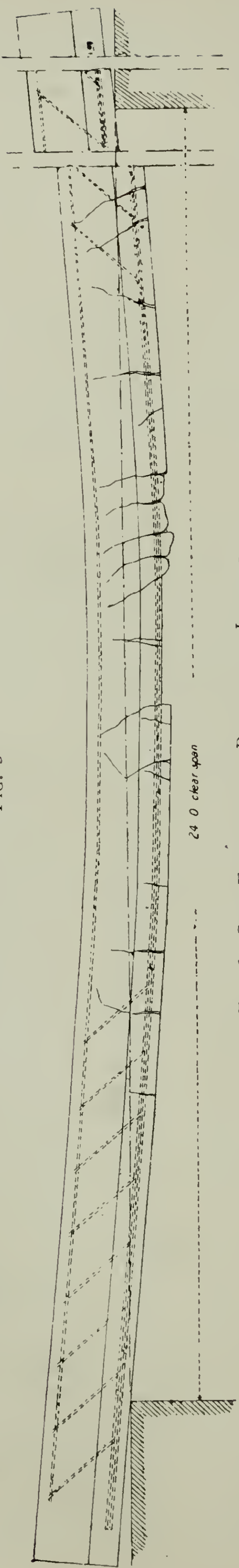


Fig. 6. Side Elevation of Beam after Loading.

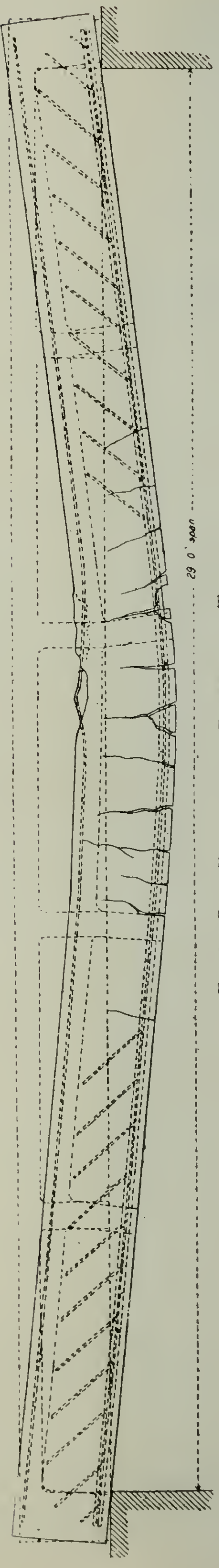


Fig 9. Side Elevation of Beam after Testing.
Dotted lines show original position

Date.	Distributed Load. Tons.	Deflection. Ins.	Remarks.
July 19	15·75	$\frac{3}{16}$	No cracks.
,, 19	31·50	$\frac{5}{8}$	Cracks near centre developed half-way up beam. Seven slight cracks either side of centre.
,, 20	40·50	1	Cracks more pronounced.
,, 20	43·20	$2\frac{3}{8}$	Cracks nearest centre perceptibly opening to fully $\frac{1}{8}$ in. right through both sides. After an hour with same load $2\frac{1}{2}$ ins. deflection.
,, 20	45·00	5	Cracks opening and more developing; went to 6 ins. deflection without extra loading.
,, 21	47·00	6	With this loading. Deflection after 24 hours $6\frac{5}{8}$ ins. without additional loading.
,, 23	47·00	$6\frac{5}{8}$	No further movement since 21st.
,, 28	47·00	$6\frac{5}{8}$	No further movement; load still on.
Aug. 9	51·50	9	Cracks developing and opening; top showing signs of crushing.
,, 9	55·35	—	Collapsed; top crushed as shown in *Fig.* 9, and top bars buckled; bottom flange touched ground; tension bars intact.

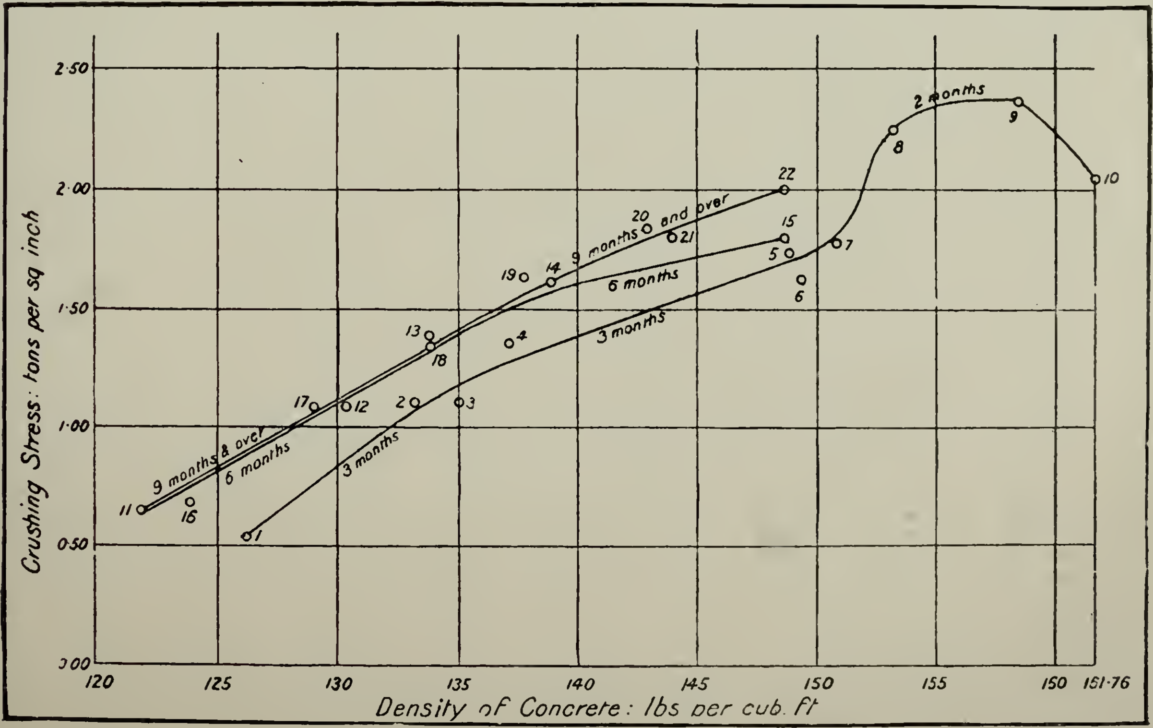
NOTE.—Dead weight of girder in the clear was 11 tons, which is not included in these weights, nor in *Fig.* 7.

Result of the test unsatisfactory, as beam failed at about half calculated breaking-load; this probably due to disposition of material in cross-section, which prevented tension-bars from being placed evenly under whole width of compression-area. Further, alteration of section at the diaphragms may have contributed to failure by affecting even deflection of beam.

TESTS ON CONCRETE CUBES.

To the foregoing tests on reinforced concrete beams we append some results of crushing tests on plain concrete cubes, the information respecting which was furnished by Mr. C. S. Meik, M.Inst.C.E., to the Committee of the Institution of Civil Engineers.

These, it will be noticed, consist of a number of tests conducted by Messrs. P. W. & C. S. Meik, and also one set of experiments at Watertown Arsenal are included. On pages 800-2 in our issue of November, 1910, we reproduced some remarks of Mr. Meik's which have relation to these tests, in which he drew attention to the fact that the compressive strength of the concrete rose progressively with the weight, the proportions of the materials remaining the same throughout. The results of these experiments are plotted in the accompanying figure, and bring out clearly the fact that the strength increases with the weight per cubic foot.



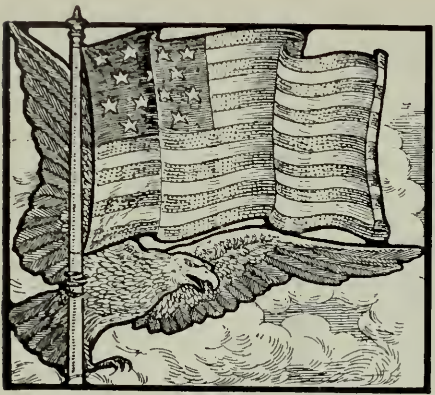
Crushing Tests of Plain Concrete Cubes.

Table showing how Strength increases with the Weight of Concrete, the proportion of Cement to aggregate remaining the same—namely, 1 to 4, except in Tests Nos. 20 and 21, where the proportion was 1 to $4\frac{5}{8}$.

No. of Test.	Authority.	Aggregate.		Propor-tions.	Age, Months.	Size of Test Block. Ins.	Weight per cu. ft., Lbs.	Crushing Stress in		Cement.	Remarks.	No. of Tests Made.
		Material.	Maximum Size of Sieve, ins.					Lbs. per sq. in.	Tons per sq. in.			
					Age of Test Block, 2 to 3 Months.							
1	P. W. & C. S. M. (Swansea)	Gravel	$\frac{3}{4}$	$1 : 1\frac{1}{3} : 2\frac{2}{3}$	3	6	126·30	1,182	0·53	Intermittent kiln	Aggregate — gravel and coarse sand from foreshore	2
2	Ditto	Gravel	$\frac{3}{4}$	$1 : 1\frac{1}{2} : 2\frac{2}{3}$	3	6	133·25	2,507	1·12	Rotary kiln	Ditto	2
3	P. W. & C. S. M. (Loch Leven)	Loch ballast	$\frac{3}{4}$	$1 : 4$	3	6	135·05	2,527	1·13	Rotary kiln	Aggregate—ballast dredged from off Ballachulish ferries	4
4	Ditto	Pit ballast	$\frac{3}{4}$	$1 : 4$	3	6	137·13	3,046	1·36	Rotary kiln	Aggregate — ballast excavated from site of Blackwater reservoir	4
5	Watertown Arsenal, U.S.A.	Pebbles	$\frac{3}{8}$	$1 : 1 : 3$	2	12	148·75	3,870	1·73	Alpha cement	—	—
6	P. W. & C. S. M. (Swansea)	Granite	$\frac{3}{4}$	$1 : 1\frac{1}{3} : 2\frac{2}{3}$	3	6	149·4	3,685	1·64	Rotary kiln	Aggregate—Guernsey granite and coarse sand from site	6
7	Watertown Arsenal, U.S.A.	Pebbles	$1\frac{1}{2}$	$1 : 1 : 3$	2	12	150·89	4,018	1·79	Alpha cement	These tests were made at Watertown Arsenal, U.S.A. (Extracted from Taylor & Thompson's "Concrete, Plain and Reinforced," New York and London, 1905)	—
8	Ditto	Trap	$\frac{1}{2}$	$1 : 1 : 3$	$2\frac{1}{2}$	12	153·34	5,021	2·24			
9	Ditto	Trap	1	$1 : 1 : 3$	$2\frac{1}{2}$	12	158·54	5,272	2·35			
10	Ditto	Trap	$2\frac{1}{2}$	$1 : 1 : 3$	2	12	161·76	4,523	2·02			
					Age of Test Block, 6 Months.							
11	P. W. & C. S. M. (Swansea)	Gravel	$\frac{3}{4}$	$1 : 1\frac{1}{3} : 2\frac{2}{3}$	6	6	121·85	1,440	0·64	Intermittent kiln	Aggregate — gravel and coarse sand from foreshore	2
12	Ditto	Gravel	$\frac{3}{4}$	$1 : 1\frac{1}{3} : 2\frac{2}{3}$	6	6	130·30	2,453	1·09	Rotary kiln	Ditto	2
13	P. W. & C. S. M. (Loch Leven)	Loch ballast	$\frac{3}{4}$	$1 : 4$	6	6	133·84	3,108	1·38	Rotary kiln	Aggregate—ballast dredged from off Ballachulish ferries	4

Crushing Tests of Plain Concrete Cubes—*(continued.)*

No. of Test.	Authority.	Aggregate.		Proportions.	Age, Months.	Size of Test Block, Ins.	Weight per cu. ft., Lbs.	Crushing Stress in		Cement.	Remarks.	No. of Tests Made.
		Material.	Maximum Size of Sieve, ins.					Lbs. per sq. in.	Tons per sq. in.			
14	P. W. & C. S. M. (Loch Leven)	Pit ballast	¾	1 : 4	6	6	138·97	3,640	1·62	Rotary kiln	Aggregate — ballast excavated from site of Blackwater reservoir	4
15	P. W. & C. S. M. (Swansea)	Granite	¾	1 : 1⅓ : 2⅔	6	6	148·6	3,998	1·78	Rotary kiln	Aggregate—Guernsey granite and coarse sand from site	6
Age of Test Block, 9 Months and over.												
16	P. W. & C. S. M. (Swansea)	Gravel	¾	1 : 1⅓ : 2⅔	9	6	124·0	1,541	0·69	Intermittent kiln	Aggregate — gravel and coarse sand from foreshore	2
17	Ditto	Gravel	¾	1 : 1⅓ : 2⅔	9	6	129·1	2,456	1·09	Rotary kiln	Ditto	2
18	P. W. & C. S. M. (Loch Leven)	Loch ballast	¾	1 : 4	12	6	133·85	3,011	1·34	Rotary kiln	Aggregate—ballast dredged from off Ballachulish ferries	4
19	Ditto	Pit ballast	¾	1 : 4	12	6	137·76	3,652	1·63	Rotary kiln	Aggregate — ballast excavated from site of Blackwater reservoir	4
20	P. W. & C. S. M. (Purfleet)	Thames ballast	⅞	1 : 1½ : 3⅓	20 (2 of which in water)	12	143·00	4,130	1·84	Intermittent kiln	Cube punned … …	1
21	Ditto	Ditto	⅞	1 : 1½ : 3⅓	Ditto	12	144·00	4,030	1·80	Ditto	Cube not punned … …	1
22	P. W. & C. S. M. (Swansea)	Granite	¾	1 : 1⅓ : 2⅔	9	6	148·50	4,467	1·99	Rotary kiln	Aggregate—Guernsey granite and coarse sand from site	6
Weights and Crushing Strengths of Stone Forming Aggregates.												
—	—	Trap rock		(felspar and hornblende)			175·0	About 11,200	5·0	—	Absorption, nil … …	—
—	—	Granite (Guernsey)		(felspar, quartz, mica and hornblende)			170·0	About 8,960	4·0	—	Absorption, 1 per cent. …	—



CONCRETE AS DISCUSSED AT THE NATIONAL ASSOCIATION OF CEMENT USERS, U.S.A.

Many interesting papers were read at the Convention of the National Association of Cement Users held in New York in December last, and we are publishing two of them in the present number. We shall deal with some of the others in subsequent issues.—ED.

SOME SPECIAL USES OF CONCRETE IN MINING.

By GEORGE S. RICE, Bureau of Mines.

(In charge of mine investigations.)

CONCRETE is not unknown to miners; apart from its use in foundations for machinery, it has been used for many years to plaster mine stoppings and dams built of brick or stone, to render them comparatively water or gas tight.

Within the last few years, contemporaneously with the advance of the science of reinforcing concrete, the general use of concrete in mining operations has been enormously extended. To-day practically all foundations for mine buildings and machinery are built of concrete, and many buildings, coal-bins, chimneys; also recently one great anthracite breaker has been built with reinforced concrete.

In many of the large new plants, concrete has entered extensively into construction underground, replacing wood, iron, brick, and stone. Its use for various purposes is rapidly extending, as its merits are better understood. The possibilities of underground application appear to widen constantly, suggesting more than mere economies, but even affecting the fundamentals of mining.

In Europe mine operations have been regarded as permanent operations; hence for many years shafts have been sunk, using brick or stone for linings, such shafts being circular or elliptical in cross-section. Where it has been necessary to use iron or steel casings to pass through water-bearing strata, permanent inner linings of brick have been used. For such inner linings, in some recent shafts, concrete has been substituted.

In this country, until the last few years, it has been without exception the practice to employ wood linings, the shafts being rectangular in cross-section. Water-bearing silts or quick-sand locations are generally avoided, and where water has been encountered in shaft sinking, no attempt was made to keep it out as in the European shafts.

In some instances where the surface quick-sands proved shallow, concrete dams were constructed inside the timber lining or coffer dams, generally these inner linings or dams were circular in section and massive, so that reinforcement was incidental. However, in sinking the air shaft of the Panama mine, Illinois, the writer used a reinforced concrete lining of rectangular section through the surface silt of sufficient strength to resist the water pressure, so as to keep the air-shaft dry. This is an important matter if the air shaft is to be used for " intaking " air, since in a wet shaft, masses of ice accumulate in cold weather, thus restricting the ventilating current or stopping it with serious results. The inner lining was put in after the shaft had been forced through the soft silt, and the outer wood curbing rested on this rock. This rock was a fissured limestone, so the shaft was sunk about 8 ft. further into the shales below—here a good foundation was prepared for the concrete lining.

As the water spurted out above in streams in putting in the massive concrete foundation, the sinking pump was temporarily checked in putting in the successive courses, and the water allowed to rise above the level of the course to be laid, so that the concreting materials could be placed in water without currents behind the form. The concrete was then tightly rammed against the shale and rock to make tight joints. When this foundation had been brought up to the level of the wood curbing, preparations were made for building up the thinner reinforced concrete walls, which were but 15 in. thick at the bottom, and 9 in. thick at the top, and about 40 ft. higher. Diagonal wood strips were nailed on the inner face of the wood curbing, and on these a tight lining of tongued and grooved flooring. This deflected the water streams to the bottom of the lining, and short pipes were placed through the concrete forms at a number of points around the shaft so as to discharge the water from behind the wood lining into the open shaft. By this method, the reinforced walls were erected in comparative dryness.

The reinforcement consisted of corrugated bars placed horizontally and vertically near the inner face—*i.e.*, toward the centre of the shaft. The vertical bars served only to bond the courses ; the horizontal bars were spaced close together at the bottom, and further apart at the top, according to calculated water and earth pressure, assuming no help from the outer wood curbing.

The horizontal reinforcement bars were bent around at the corners of the shaft, which were bevelled. The shaft had two compartments about 9 ft. by 10 ft. and 9 ft. by 5 ft. in the clear, respectively, with an $\frac{1}{8}$-in. concrete partition between. When the concrete had sufficiently hardened, the drainage pipes were plugged, and the walls then served their object as a dam. There was a slight seepage at several points, but this gradually stopped.

DROP SHAFT SINKING.

Where the glacial drift or water-bearing silt is very deep, special methods of shaft sinking have to be used.

The freezing system and the drop shaft system have been highly developed in Germany and France, and to a point both are very successful. Reinforced concrete is adaptable for linings, but with either system it has not as yet been employed to any considerable extent.

In this country little has been done with either system, chiefly owing to shaft sinking conditions generally being easy. More recently there has been occasion for the penetration of water-bearing silts, and one reinforced concrete casing has been successfully sunk in the Lake Superior iron region. The plan of the casing was similar to the ordinary drop shaft casing of brick so extensively employed in England—namely, to build on top of a steel shoe which drops as the excavation proceeds. Skin resistance to descent of the casing is the chief obstacle usually encountered, so far as the casing is concerned, and this has to be overcome by weighting.

The concrete bridge pier caissons sunk in between river silts, and the caissons used in the vicinity of New York for shafts preliminary to tunnelling, are of the same nature as drop shaft casings, except that their vastly greater size and weight relative to depth makes the problem of sinking them simpler.

The method of using reinforced concrete casings seems applicable to many cases where it is necessary to sink through bad ground, modifications being made to suit the condition of sand or glacial drifts that may be encountered.

A most interesting method used in connection with shaft-sinking through water-bearing ground has been developed in the Pas-de-Calais coal district of France, which is termed " Cementation."

The coal measures of the districts are overlain with bedded marls and chalks, more or less fissured, and the fissures in some place are so filled with water that ordinary methods of shaft sinking would fail. Heretofore the freezing system has been successfully used, but the new cementation method, the writer was informed, could be employed at less cost. Interesting particulars of the method are given in a paper by J. Lombois, principal engineer of Mines de Bethune. The process is to drill a set of holes in the water-bearing ground, six in number, arranged in a circle surrounding the site of the proposed shaft, and then pump in, under pressure, a cement grouting until the fissures and interstices are filled. Shaft sinking is then proceeded with as it would be through ordinary rock-strata. The system seems applicable to many situations where water is encountered in either shaft sinking or tunnel driving.

SHAFT LANDINGS OR BOTTOMS.

In Europe it has long been the custom in collieries to secure the " landings " adjacent to shafts with masonry side walls and arched roofs, both for fire protection and for permanence.

Such arched passages or tunnels contain from two to four tracks, and sometimes where double-decked cages are employed, and are arranged with corresponding upper and lower stages, a considerable height of tunnel is required.

In this country, until recently, with rare exceptions, the " bottoms " have been lined with timber only. Such mine timbers, if of white oak, last from 5 to 8 years, depending on whether the natural conditions foster dry rot, and if of black oak or white pine, shorter periods. As the cost of timbers is greater than the first cost, if a mine lasts over twenty years, it is manifest that wood timbering is in the long run more expensive, and there is always a great danger of its taking fire.

Where the bottom is tc be arched, brick is an excellent material to use, and a substitution of concrete is wholly a question of relative cost. There are, however, many situations where there is a strong " cap-rock " over the coal that is difficult and expensive to brush, in making room for the arching ; moreover, such cap-rock may have considerable strength as a roof. Under such conditions, the practice has arisen in recent years to use large (15 in. to 16 in.) **T**-beams for collars, across the passage, resting the ends on side walls, and to lag with wood over the beams. Such a construction makes a good appearance and should be fairly durable, but it is open to objections : the wood lagging will rot and be difficult to replace without disturbing the roof and, in case of an explosion, the beams offering considerable surface, are blown down or, if struck by flying timber, may be broken. There appears to be an excellent field for the application of reinforced concrete under the conditions cited—namely, where a flat roof is desired at a cheaper cost than that of **T**-beam construction : also where greater durability is desired and freedom from the disadvantages mentioned above.

Much will have to be done in the way of determining what should be the strength ot the flat concrete arch acting as a beam under different conditions of natural roof, and in the development of methods of erection under a horizontal roof stratum.

LINING ENTRIES WITH REINFORCED CONCRETE.

The roof stratum over most coal seams is shale, which, when hard, is called slate by the miners. Shale weathers badly, and in the majority of the coal mines the entries must be timbered more or less continuously. If the shale were protected from the weathering section caused by the ventilating currents it would require little support.

This principle has been recognized by the Bethune Company, which operates in the Pas-de-Calais district of France, so that in developing a new mine, a few years ago, they decided to line all the passage ways with reinforced concrete. At the time of the visit of the writer in September, 1908, about two miles of such lining had been constructed, and while of light construction, it had yielded slightly at only one point. The side walls, which are slightly concaved, are about 4 in. thick, and the low arch about 5 in. thick at the crown. The reinforcement consists of plain iron rods parallel and at right angles to the axis of the passage-way. Two cross-sections of passages are employed, the main galleries about 8 ft. wide in the clear and about 6½ ft. in height. The secondary passage-ways are about 6½ ft. in width in the clear and about 7 ft. high. The forms were ingeniously constructed as to be readily transported and set up quickly. The same gang of men is steadily employed on this work so as to become very proficient.

In the case of the Bethune Company, their enginemen informed the writer that the cost of maintenance of the mine in which the lining was done was only one-fifth of the average cost of the maintenance of the other mines of the company in the same concession.

Other advantages of concrete-lined passage-ways are manifest to a mining man. There is no blockage of traffic by falls ; watering the roads can be done freely and little is required to keep the passage free from dry coal-dust, that great menace to miners and the cause of propagation of so many great explosions. Moreover, with refuge holes, there is less danger to employees through passing trips of cars. In timbered entries, if cars jump the track, they are liable to knock out timbers and bring down the roof on either the trip rider or a man standing at one side. Good lighting tends to reduce haulageway accidents. A concrete-lined passage is easily lighted since the surface is smooth and light coloured, and if desired can be cheaply white-washed.

OVERCAST STOPPING AND DAMS.

Concrete has already been adopted by many mine operators in their building of overcasts (air current crossings). These have usually been of massive construction. If reinforcement were employed, the cost might be considerably reduced. Reinforcement of concrete might lead to economy in the erection of mine stoppings and dams. Some operators use small coal for stoppings in place of crushed stone. If the coal is of a tough nature, and properly screened, in massive stoppings this is economical, but often too much coal dust is used, so that an excess of cement is required and the concrete is very weak. Such concrete is not suited for stopping or water dams where there is likely to be much pressure thrown upon them, or in the case of stoppings if subjected to heat.

CONCRETE PROPS.

There is undoubtedly a large field for the development of a system of concrete props moulded and hardened on the outside of the mine. Props are a large item of expense in most collieries. In the average colliery of this country one room prop is required for every 8 to 12 tons of coal produced, say 1 to 10. Timber props cost from 10 to 20 cents each, so the cost per ton of coal produced is from 1 cent to 2 cents. The cost will undoubtedly rise rapidly in future, as the timber reserves of the country become exhausted.

In this country, timber props are rarely recovered, as they are abroad, where the long wall method of mining is general. In the room and pillar system, which is the one usually employed in this country, the props often stand so long as to dry rot and not make it worth while to try to withdraw them in pulling pillars. In collieries in which the conditions are such that the props could be withdrawn by " Prop-drawers," such as are used extensively in England, concrete props might be a great economy beside conserving timber resources.

CONCRETE TIMBER SETS.

There appears to be an even better opportunity for the development of a system of outside constructed concrete timber sets than there is for colliery room props, since timber sets are intended to be more permanent and required to be stronger.

In collieries each timber set consists of a collar and two legs. The collar is perfectly square in cross-section, the legs may be either round or square. It would be necessary to have legs of different lengths, but this entails no particular difficulty ; small differences are easily taken care of by picking the footing deeper or wedging the legging over the top of the collar.

That there is a field in this direction of concrete timbers is shown by the increasing rise of **T**-beams for collars and for legs. Concrete timbers for equal strength should be as durable and should be cheaper.

The opening for concrete posts and timber sets in certain kinds of metalliferous mining appears to be as great as in collieries. Often great strength is needed, and in some parts of the country, as in the south-west mining districts, big timbers are difficult to obtain and very expensive. Crushed rock for the concrete is always at hand in metal mining operations, and Portland cement can now be obtained at moderate price in any part of the United States. Reinforcing material is often at hand in the scrap iron pile.

In some cases the large concrete timbers could be built in place, but in many cases, owing to the condition of the roof, it would be necessary to have the full strength of a concrete timber at the time of erection ; hence the necessity of having concrete timbers constructed and seasoned in advance of setting up.

In the development and testing of concrete props and timbers, as well as the concrete linings previously mentioned, there would appear to be need of work on the part of the Bureau of Mines through the facilities they possess.

The use of concrete for outside mine buildings has been merely mentioned in this paper, as such work is either identical or very similar to what concrete builders are thoroughly familiar with. But it is not intended to give the impression that the amount of this work is small, or that it is unimportant. Every year there are heavy money losses from fires in tenant houses and mine structures, which, in the case of shaft houses, have sometimes caused the loss or temporary loss of the mine, involving direct losses of thousands of dollars.

If concrete builders would give the subject the same study that they give to bridges and manufacturing buildings, and be prepared to take up the construction of mine buildings of various kinds with promptness and vigour, there appears to be a large field of usefulness, productive of improved construction and adequate fire protection.

SOME NEW METHODS IN SIDEWALK AND CURB AND GUTTER CONSTRUCTION.

By JEROME B. LANDFIELD.

It is my task to-day to endeavour to point out certain developments in sidewalk and curb and gutter work, and to make some suggestions as to the best methods to be followed. What I have to say is the result of practical experience and careful study, together with an extensive observation of concrete work in nearly every part of the country.

The effort of the report of the Committee on Uniform Specifications last spring has been far-reaching, and has done more to improve the quality of sidewalk and curb and gutter work than most people realise. It has not only guided many a city engineer in making up his specifications for municipal work, but it has suggested to many a contractor improvements in his own methods.

It was manifestly impossible for this report to go into all the details of method and to prescribe exactly how the contractor should do his work in all particulars. Something had to be left to the judgment of the contractor. As far as they went, the uniform specifications were excellent. They did not permit the contractor to let his foundation course set before putting on his top course ; they provided that retempered concrete should not be used ; they forbade the sprinkling of dry cement on a wet surface to dry it for finishing quicker, and they prescribed certain other important details.

What I have to offer for your consideration are—first, the developments of the past year in the matter of some new devices for simplifying and reducing the cost of sidewalk and curb and gutter work ; and, secondly, some improvements in method that are closely connected with the use of these devices. The chief of the devices to which I refer are steel forms or moulds to take the place of the ordinary wooden ones heretofore used, and I am free to say that it is doubtful if in the whole field of concrete work a more important invention has been put on the market during the past year. There have been several stages in the development of steel forms, beginning with metal division strips and templates for making expansion joints.

METAL FORMS.

The question for the inventor was how to make a metal form, the parts of which should be mutually self-supporting and easily taken apart, and yet at the same time have no projections above the surface to interfere with striking off and finishing. It was evident that if the division plate was to be flush with the side rail, the only way of securing them together would be for a tongue of the division plate to penetrate the side rail, and this would mean that the side rail would have to be removed before the division plate could be lifted, and this must be done while the concrete was still green. This was the stumbling-block, and he attacked it boldly. After all, why should not the side rails be removed immediately ? To protect the edges ? Of course not, for the whole surface had to be protected against intruders in any case. The idea was revolutionary, but it was worth trying, and the result was highly satisfactory.

The idea was first applied to sidewalk work. Simple steel channels 4 in. high, and having 1-in. flanges, were used for side rails. At regular intervals were vertical slots, and the ends were fitted with a tongue and socket arrangement for joining successive side rails together. Division plates were made of the same height, and with tongues adapted for projecting through the vertical slots in the side rails, and being locked by lugs on the outside.

When a system of steel forms was placed in operation on sidewalk work, advantages appeared that were not at first thought of. Of course, they did away with the annoying lumber bill, and they guaranteed clean-cut expansion joints without any additional expense. But they saved much more labour than had been anticipated. In the first place, one man could set up as many feet in an hour as two good form setters of wooden forms could in half a day. The measuring was already done by the regularly placed slots in the side rails, and there could be no mistake about it. When one side was brought into line, the other side had to come into line without further work. Adjustment to grade was simple, and required no changing of stakes, and, best of all, the forms stayed in place without any staking or bracing.

EXPANSION JOINTS.

Before taking up the adaptation of this system to the building of curb and gutter, I would like to call attention to certain points in sidewalk work that are frequently overlooked. I do not need to point out the supreme importance of the expansion joint. A great many contractors, from districts where there is little or no frost, are inclined to regard the expansion joint as unnecessary, but this is a great mistake. Only a few weeks ago, when I was discussing the situation with the best posted man in California, he said to me : " Clean-cut expansion joints would eliminate 50 per cent. of all the sidewalk trouble in this State." The expansion joint is a necessity ; but there are now in the market so many satisfactory division plate devices that it is no longer economical to chop through the concrete ; and to fill the joint with sand is really absurd.

FINISHING OFF TOP COAT.

I have two suggestions to make as to the methods of sidewalk work—one has to do with the consistency of the top coat, the other with the manner of finishing the surface. On the question of consistency of the top coat, the book authorities are divided or non-committal. I have given this subject a good deal of study and wide observation, and as a result I am going to offer for your consideration a method that will astonish many of you. It consists in putting in a top coat with only a little water in it, and then tamping it to bring sufficient moisture to the surface for immediate finishing. This not only makes a fine bond with the foundation course, and gives you a dense close-grained top, but it insures you against checking and crazing. I have heard it objected that this method would add to the cost, but when the contractor tried it he found that it was cheaper to pay for a little more tamping than to have finishers waiting around for the surface to dry out.

SURFACE FINISH.

The method of finishing the surface consists of two operations—striking off and floating. When the top coat has been tamped and the surface is just right for finishing, we take a piece of angle iron with a handle at either end to use as a strike-off stool. One man on each side of the walk grasps this by the handle, and they proceed to strike off the surface with a sort of sawing motion, each in turn bringing his end forward so as to prevent the surplus material from being brushed off at the side. With a little practice they become very proficient in this. In fact, this method of striking off facilitates floating to such an extent as to make a considerable saving. Of course, the surface may be struck off when wooden forms are used ; but the side rails are frequently rough and uneven, and the stakes are a hindrance. With steel forms the method works to perfection, for the strike-off stool moves easily along, and the resulting surface is absolutely even.

The floating of the surface is a point on which there are many opinions. I presume that a majority of sidewalk men to-day finish their work with a trowel, but I am inclined to consider this bad practice. The improved practice is to strike off the surface as described, and then finish it with a wooden float. A large number of concrete men use this method now, but the practice ought to become universal. As soon as the walk is floated the surface should be lightly brushed with a dampened brush. The result is a handsome even surface, on which there is no danger of slipping, and which in appearance excels the best natural stone. In mixing the top coat it is very desirable to use a certain amount of crushed granite or some similar material with your sand in order to make a more durable surface, and at the same time avoid the dirty yellowish colour that common sand frequently gives.

CURB AND GUTTER CONSTRUCTION.

There is one branch of street concrete work that is particularly interesting at the present time, and that is curb and gutter construction. It is not necessary here to point out the numerous advantages of curb and gutter over straight curb, for the public generally is coming to realise that this form of construction is not only the most satisfactory from a practical standpoint, but that it finishes and beautifies a street to such an extent as to add more than its cost to the value of real estate.

The best method of curb and gutter construction was made last summer, when all steel forms were developed. Although the plan looked all right in theory, I for one was inclined to be somewhat sceptical as to its success in practice until it had been thoroughly tested. The one point that disturbed me was the question of the curb standing up properly if the forms were removed while the concrete was still green. But this had been foreseen, and while some tests showed that with care it would stand up all right for a vertical curb, the precaution was taken to give the back of the curb a batter of 1 in. on 12. This not only gave the curb stability while setting, but made a stronger and better curb.

The steel forms, of which several varieties have been placed on the market by different manufacturers, deserve a detailed description. In the first, a series of division plates or templates are provided. These are shaped exactly to a cross-section of the curb and gutter to be laid, except that in front and rear are slatted tongues. These tongues are the means by which the front and back moulds are held in position, and are variously placed according to the size and number of channels it is desired to use for this purpose. For example, if the curb is 12 in. high at the back and the gutter is 6 in. or 7 in. thick in front, it is convenient to construct the templates to accommodate two 6-in. rails at the back and one 6-in. rail in front. This simplifies the outfit, as the rails are then interchangeable. On the other hand, contractors sometimes find it desirable, when working on sidewalk and curb and gutter in the same locality, to have the templates made with tongues to accommodate three 4-in. rails at the back and one 4-in. rail in front, and this enables them to use for curb and gutter work side rails which may also be used for sidewalk work.

The back of the template is not made vertical, but is given a batter 1 in. on 12 in. The object of this is to give stability to the back of the curb while the cement is green, and remove any danger that might result from the immediate removal of the forms. Besides this consideration, it is a desirable feature of curb and gutter construction.

The setting of the forms is a simple matter. The best method is to drive stakes to grade at intervals in the excavation along the front line and back line of the curb and gutter. The forms may then be locked together and set up on these stakes when further levelling is necessary. They are then ready for filling with concrete. It is best to mix this without too much water, stiff enough so that it will not quake when tamped. When the forms have been filled with concrete up to the level of the gutter, a face mould for the curb is put on. This consists of a 2-in. plank, the lower edge of which has been rounded to conform to the curve of the template at the junction of curb and gutter, and which is held in place by clamps or braces. A simple method is to secure it in position with three or four small sticks, just long enough to reach to the front rail.

In filling in the concrete for the curb, care is taken to face the curb with rich or top-coat material. The top of the curb and the surface of the gutter are then treated to a layer of top-coat material mixed stiff and tamped.

The plank is removed, and the whole surface is struck off with a piece of angle iron, using successive templates as guides. The surface is finished at once with a float and brushed.

The final step is to knock out the keys and remove the forms, which is done within a few minutes after finishing. The templates slip out easily without disturbing the surface, after which the jointer may be used. The section of forms taken off is then set up further along on the work, and in this way the forms are used over and over again the same day. With 50 lineal ft. of forms a gang can build at least 300 lineal ft. of curb and gutter per day.

STRAIGHT CURB.

Still another adaptation of steel forms is possible, and that is in the building of straight curb. For this purpose templates are made 18 in. in height, 6 in. wide at the top, and 9 in. wide at the bottom, having a batter front and back of 1 in. on 12 in. Three tongues on each accommodate three 6-in. side rails front and back, and the whole mould is set on stakes a little above the bottom of the excavation. The concrete filling this space below the forms and out to the sides of the excavation makes an integral base for the curb. The forms are filled with concrete, and the top front rail is first removed in order to float the face. The other rails are then taken off and the templates drawn. The end templates are left on at the close of work, and care is taken to brace them. In general the strain on the forms is greater in straight curb than in curb and gutter work, and it is desirable to brace the forms occasionally to prevent them bowing out under heavy tamping.

THE NEW ROYAL AUTOMOBILE CLUB.

In our issues of February and July, 1910, we gave detailed descriptions of the concrete and reinforced concrete work at this building, and under "Recent Views" in this number will be found an account of the architectural and engineering features of this important structure.

The series of articles, of which the present one forms the conclusion, were prepared for us by Mr. Albert Lakeman, Hon. Medallist Construction.—ED.

REINFORCED CONCRETE ROOFS AND STAIRCASES.

SOME notes have already been given on the reinforced concrete floors and roofs generally, but no detailed description has been given of the work to the sloping roofs, which is illustrated on pages 191 and 192. These sloping roofs occur both in the front and back portions of the building, the fourth floor only being constructed thus in the former case, while in the latter case the slope runs through the height of the fourth and fifth floors.

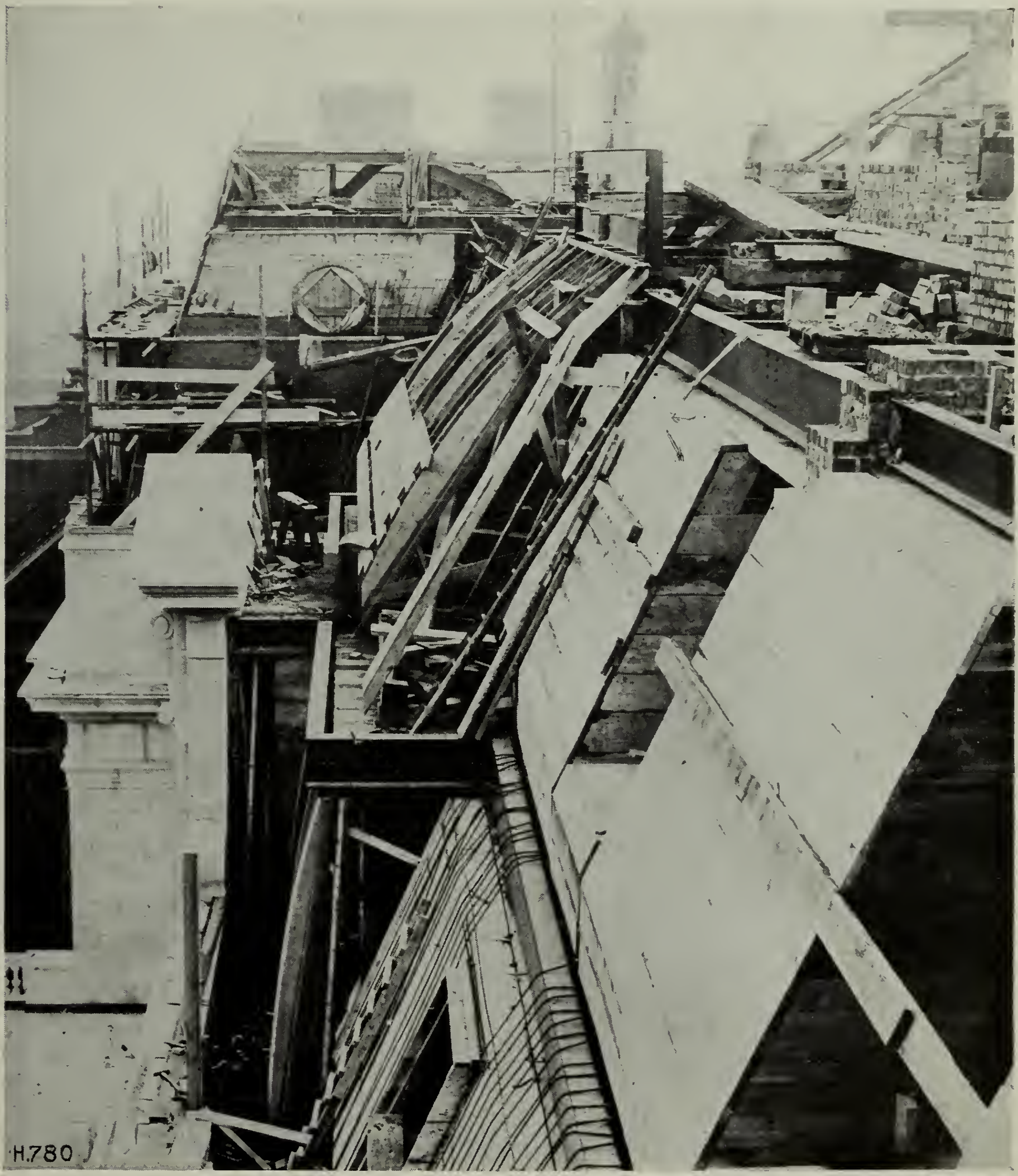
The front roof facing Pall Mall is carried right through the full width of the building—viz., 228 ft. without a break. The height is about 10 ft. 6 in. from the fourth floor level to the asphalte flat above, and the pitch is 60 degrees. The thickness of the concrete employed was 4½ in., and the reinforcement consisted of ⅓-in. indented steel bars, spaced at 10-in. centres, these being bent over the rolled steel joists, which acted as trimmers at the intersections of the sloping roof with the flat roofs above and below. In addition to the vertical reinforcement ⅓-in. bars were placed horizontally at 2-ft. centres to distribute temperature stresses.

Several dormer window openings were required throughout the front, and these were formed in such a manner that the windows are set back within the roof and not allowed to project in the usual manner. This rendered it necessary to form the cheeks and the small flat at the bottom of each window in concrete also, and the same thickness was employed as in the main roof slope. Vertical reinforcement was provided in the cheeks and all the cross bars of the main reinforcement were bent round and continued into this portion.

The small flat below each window was strengthened by the addition of ⅓-in. bars at 10-in. centres, and two similar bars were placed at the head and the bottom of each opening to act as a tie, and round these the vertical bars were bent, which could not be continuous on account of the opening.

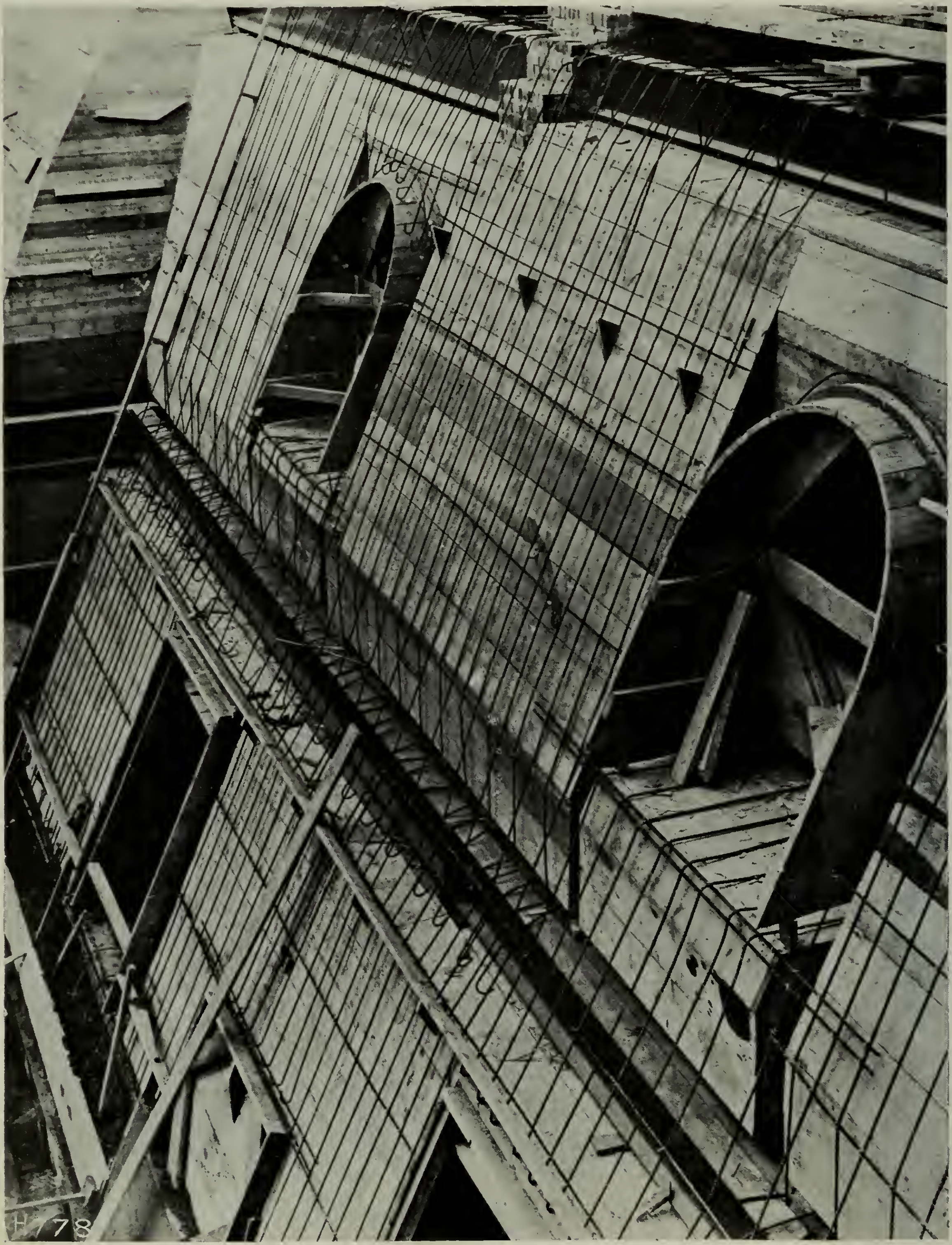
In the case of the back roof, this was about 20 ft. 6 in. in height, built with a pitch of 65 degrees, and cut up by a central curved pavilion and two straight sloping pavilions at the ends, which were carried up above the general roof level. Steel framing was introduced, however, at the fifth floor level, which is situated about halfway up the slope, thus cutting up the roof into two portions, as will be observed from the illustrations already mentioned. Every alternate bar was, however, made continuous, while the others were hooked over the steel framing.

The photograph on page 191 illustrates the shuttering for this roof, and one of the end pavilions and the central curved pavilion can be seen during construction, while that on page 192 gives a detail view of some of the reinforcement in position, and shows the method of forming the openings. The end pavilions were built at a different pitch to the main roof slope, having an angle of 75 degrees. All the sloping roofs are covered with green slates nailed to a double set of



Shuttering to Back Roof.
THE NEW ROYAL AUTOMOBILE CLUB.

battens, and all the curbs, hips, and window surrounds are covered with copper. The flat roofs are covered with asphalte laid on a cement bed worked to the necessary falls.



Formation of Window Openings.
THE NEW ROYAL AUTOMOBILE CLUB.

The proportions used and the method of mixing the concrete for this work was the same as that described for the reinforced concrete floors in the previous article.

With one exception all the staircases were constructed in concrete, the methods employed varying considerably with the size and importance of the staircase. In the majority of cases the form adopted consisted of steel channel stringers and concrete steps, strengthened with small steel tees, but plain and reinforced concrete were also used, the latter material being adopted in complicated positions, thus proving its adaptability, which is not the least one of its many advantages.

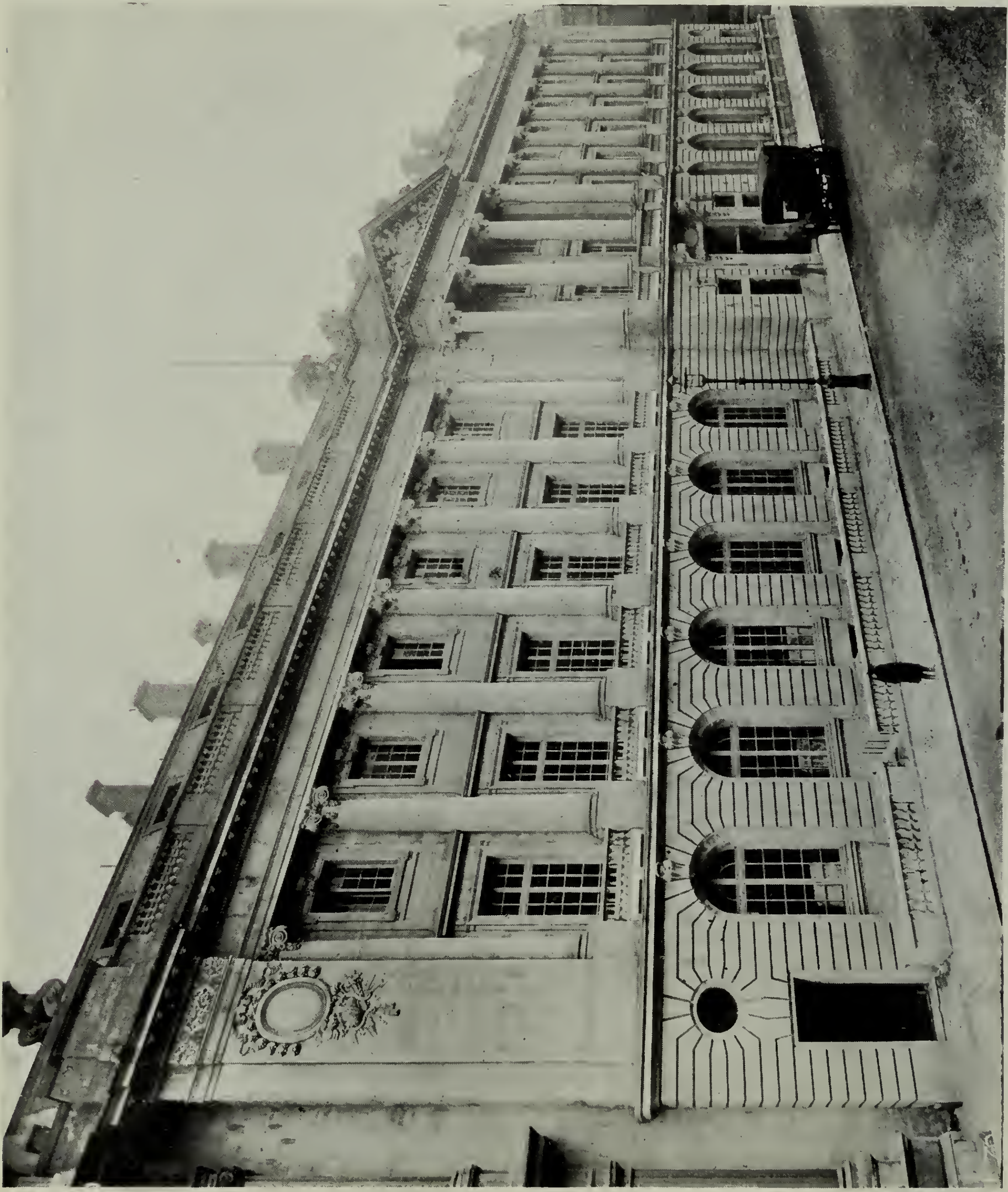
There are fourteen staircases in all, and the one exception to the use of concrete is the waiters' staircase leading from the kitchens on the lower ground floor to the restaurant on the ground floor, which affords a direct hand service, and it was necessary to use timber in this staircase, as this material has more " give " than concrete, and does not prove so tiring to the feet when continually running up and down the flights. The main staircase is that leading from the ground to the fifth floors, situated directly off the large central elliptical vestibule, with flights 5 ft. 6 in. wide around an open well. The staircase itself occupies a space 27 ft. 6 in. by 16 ft. 6 in., and the steps are formed in concrete with rolled steel joists at each half landing and floor level, to support the 10-in. by 3½-in. raking steel channels, the latter carrying the concrete stringer and the outer ends of the steps, the inner ends of the latter being supported by the 14-in. walls surrounding the staircase itself. These raking channels are cleated and riveted to the steel joists with all necessary ramps, and the steps themselves are further strengthened by the addition of 2-in. by ½-in. steel tees, which form a core, and ¾-in. steel tie rods, which serve to tie the channels back to the walls.

One of the principal features in the design of the stairs which greatly affected the construction was that of allowing no beams or projections to show, and a continuous flowing soffite and stringer was obtained which gives a pleasing effect and conveys the idea of graceful and easy ascent when looking up the staircase. This necessitated the use of more concrete than would have been required if projections had been allowed on the underside, but the effect of the staircase would have been entirely lost. The concrete stringer which covers the raking channel is 2 ft. 2 in. deep and projects 2 in. above the steps and the same distance below the soffite.

The landings, treads and risers are finished with Echaillon stone 2 in. and 1½ in. thick, this being a very hard cream-coloured French marble, which is laid unpolished, having an effective appearance combined with excellent wearing properties, while the walls and stringer are finished in " stuc," which is plaster composed chiefly of stone dust and plaster of Paris, applied and jointed to imitate stonework, which it closely resembles.

The small service staircase, which runs from the basement to the fifth floor, adjoining the service lifts, is constructed on the cantilever principle, with an open well in the centre, each step obtaining a certain amount of support from one wall only and the step immediately below it. The width of the flights is 2 ft. 9 in., and each step is strengthened by a small steel tee core, while the concrete is composed of cement and granite chippings in the proportion of 1 to 4. The steps are finished with Mason's patent treads and 1¼ in. of granolithic.

The reinforced concrete stairs are generally used in the case where complications occurred, and a typical instance is that of the staircase leading from the lobby adjoining the lounge on the ground floor to the large restaurant on the first floor. The shape is so peculiar and winding and the points available for support so peculiarly situated, that it would have been impossible to shape ordinary steel channels and joists as necessary ; reinforced concrete was therefore employed with reinforced stringers, steps and soffites, and the desired effect was obtained. A further instance is that of a small staircase 2 ft. 6 in. wide which has a support on one side only, and in addition has to pass over a duct used for



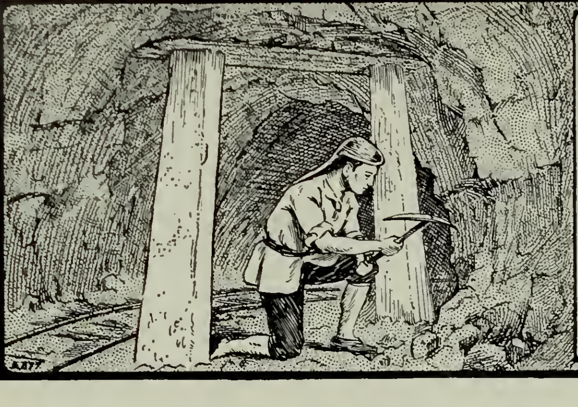
View of finished building.
The New Royal Automobile Club

ventilating purposes where every inch of space available was very valuable. A portion of the steps required to be designed as cantilevers, and these are reinforced with two ½-in. indented steel bars on their upper surfaces, while a portion of the flight itself was required to act as a beam where passing over the ventilation duct previously mentioned. This rendered it necessary for some of the lower treads to form an abutment for the beam portion, and these were reinforced with three ½-in. bars instead of two, as the longitudinal reinforcement in the beam portion was designed to distribute the pressure over three treads in each case. The bottom flight, which is about 12 ft. long, was designed in such a manner that it was independent of any support at the sides, having ½-in. bars spaced at 3-in. centres longitudinally for the full length, with transverse bars at 12-in. centres, while the minimum thickness of the concrete was 6 in.

The finished structure, generally, is probably the finest building in London with its bold elevations in Louis XIV. style, built entirely in Portland stone. The façade to Pall Mall is illustrated on page 194. The total cost of the building is about £250,000, and the internal arrangements are complete in every detail. An elaborate system of heating and ventilation has been installed throughout, and, although the structure is of the fire-resisting character, fire alarms and hydrants have been provided at various points on each floor. Two complete vacuum cleaning installations have been put in to facilitate speedy and thorough cleaning throughout, and pneumatic ejectors have been installed to deal with the drainage of the lower floors, which come below the level of the main sewer. The accommodation is palatial, and a member residing at the Club will find that all his requirements have been provided for in the various departments. A general idea of the planning and the principal apartments was given in the previous article and need not be again described.

The indented bars for the reinforcement were supplied by the Patent Indented Steel Bar Co., of Westminster.

As previously stated, the joint architects for this building were Messrs. Mewes & Davis and Mr. E. Keynes Purchase, while the consulting engineer for the construction was Mr. S. Bylander. The general contractors were The Building Construction Co., of Cockspur Street, S.W.



FORMS FOR CONCRETE.

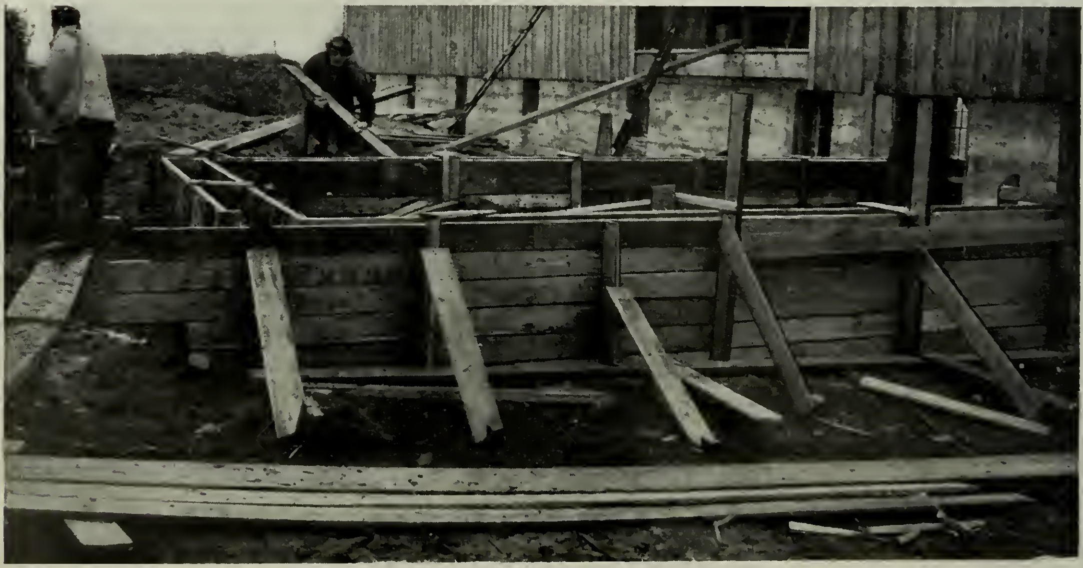
Schemes for Saving Time, Labour and Lumber.

The following is taken from a pamphlet sent out by the Association of American Portland Cement Manufacturers, giving specific and authoritative directions to enable farmers to erect forms for concrete with their own farm labour.—ED.

Since freshly mixed concrete is a plastic material, forms of some kind are necessary to hold it in place and in shape until the cement sets up and the concrete becomes hard. Lumber, though expensive, is the material most commonly used. By exercising his natural ingenuity and customary care in the matter of construction of forms, the farmer has built so cheaply of concrete that his cost statements are frequently doubted by the builder in the city.

Much of the work done on the farm requires almost no forms at all. In this class are walks, floors in buildings, and feeding floors, which will be dealt with in a later article.

Forms Must be Tight.—The first requisite of good forms' is that they should be tight so that the liquid cement may not run out between the cracks, cause pockets or hollows and thus ruin the look of the work as well as decrease its strength. Consequently straight boards are most desirable unless one chooses to fill gaping cracks with stiff clay and tack strips over them. Dressed lumber is usually straightest and yields a neater finish to the concrete. But for ordinary purposes rough lumber is sufficiently good. Naturally the siding must be stiff enough not to bulge out of shape when the forms are first filled with concrete. This does not mean that very heavy siding is necessary. In fact, 1-in. boards are usually sufficiently strong. The bulging may be prevented by setting 2-in. by 4-in. studding from 20 in. to 30 in. apart, according to the thickness of siding boards or sheathing used.



Forms, showing Boards projecting beyond Corners.

The Primary Principle: Save Lumber.—The thoughtless cutting of boards into short lengths means a waste of lumber and a useless increase in the cost of concrete. Unnecessary nailing not only calls for more nails, but adds to the difficulty of removing and the danger of splitting and ruining the boards. The reason that concrete is so unusually cheap for the farmer is that he plans his forms to spoil as little lumber as possible, and he finds a use for all of the lumber after it has served to hold the concrete in place. In this way the material for forms costs practically nothing.

Little Saving Devices.—Most concrete work on the farm is built in what is known as the *box form,* which, with variations, consists of one box within another between which the concrete walls are moulded. Such forms are used especially for walls of buildings, tanks and troughs. Ordinarily the studding need not be cut in lengths equal to the height of the wall : it may, without inconvenience, be allowed to project above the top of the siding. Nor does it need to be sharpened (and later battered up at the other end) for driving into the ground. There is a quicker, easier and cheaper way. Set the ends of the studding on the ground and hold them in their proper position by a timber, called a *liner,* lying on the ground against them, or " toe-nail " the ends of the studding to a plate which will serve the same purpose. Stakes driven into the ground and against the plates or liners will fix them firmly in place. The studding may be held plumb by bracing it with odds and ends running from the top to stakes driven into the ground a few feet away from the form. If the forms are so high and will be filled so rapidly as to render possible the springing of the studding, tie the opposite pieces together by means of pliable wire passed through the joints in the siding. Space the forms at the top by means of cross cleats.

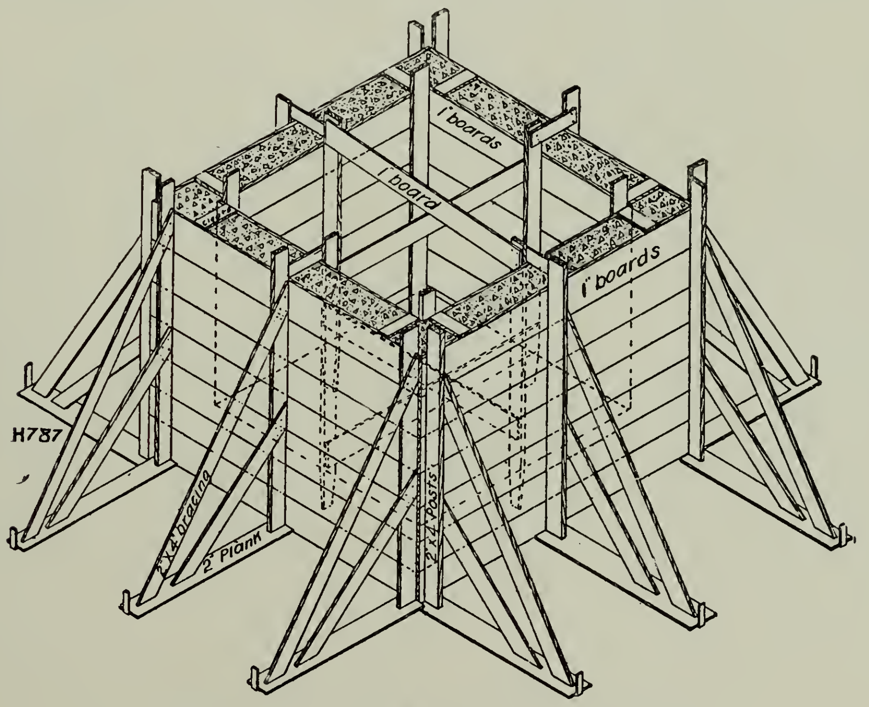


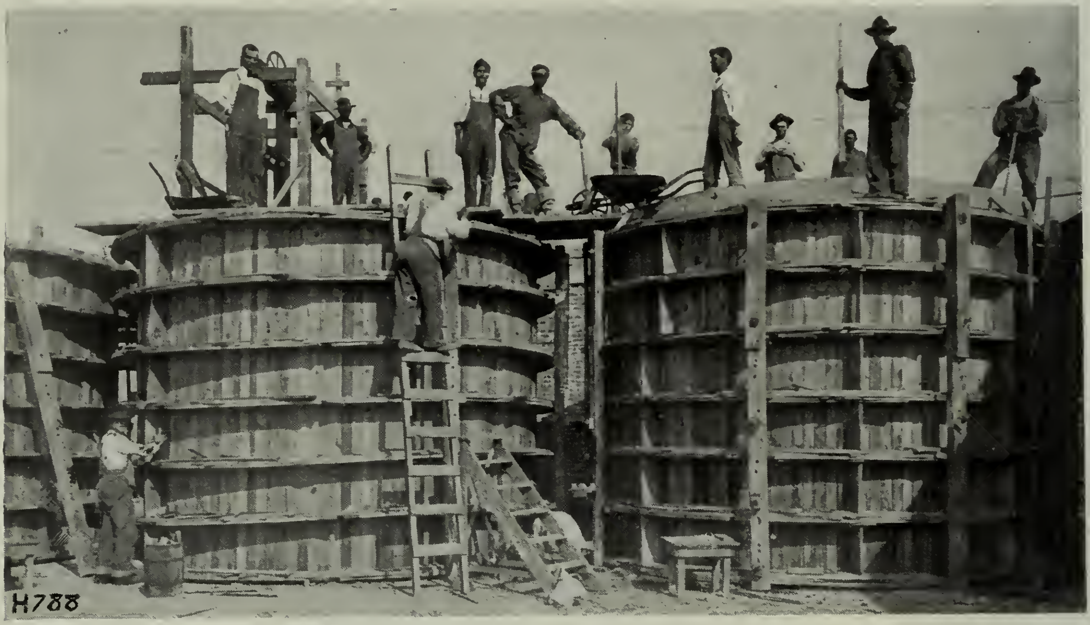
Diagram showing Forms filled with Concrete.

For the outside wall of box forms boards of full length need not be cut at all. The extra length may be allowed to extend beyond the corners. This saving cannot always be effected with the inner wall, yet odd pieces of boards may often be used in such a way as to prevent useless cutting. In nailing on the siding, arrange the boards so that all end joints will not be made on the same upright. If the lumber is crooked, draw the boards together so as to prevent cracks. Since the siding is generally between the studding and the concrete, heavy nailing is not needed to hold it in place until the concrete comes against it. In placing the concrete avoid unnecessary lifting by leaving off a few of the boards at the top of the form until they are needed. However, if chips or blocks fall inside the forms, carefully remove them before proceeding with the work.

See that the forms are lined up properly before beginning to fill them, as they *must not* be disturbed after the concrete is in place.

HOW TO CLEAN FORMS FOR CONCRETE.

If new forms are wet before the concrete is placed and allowed to remain in position until it has thoroughly set, bits of concrete will seldom stick to them. For very particular work, or where forms are to be used more than once, it is advisable to coat them, previous to erection, with soft soap or oil. Linseed, black or cylinder oil is suitable, but kerosene is not good. Upon taking down the forms immediately clean off all bits of concrete clinging to them. For this purpose a short-handled hoe is convenient, but it must be used with care so as not to gouge the wood.



FORMS FOR ROUND CONCRETE TANKS.

THE PLACING AND PROTECTION OF CONCRETE.

All other things being equal, the strength of concrete is dependent upon its density or compactness. Where possible, the easiest way to render concrete dense is by mixing and placing it wet. For very wet concrete the forms must be tight, so that the liquid cement cannot escape. To give a neat finish to the surfaces, which will later be exposed, force the larger stones back from the outside by running a straight spade or a wooden paddle down in the concrete next to the wall forms and working it back and forth.

It frequently happens that very wet concrete cannot be used. To make a drier mix dense and strong, tamp or ram it into place with a heavy wooden or iron tamper.

Exposed surfaces of freshly placed concrete should be shaded to protect them from rain, dust and the hot rays of the sun. Freezing injures freshly placed concrete. Hot water and salt are sometimes used to counteract the frost action ; but, on the whole, it is better to attempt no outside work in winter. During the early months of spring and autumn see that no frozen sand, gravel or rock is used in the work. *In summer* ordinary forms for walls supporting no loads may be removed after the concrete is three days old, but *in cooler weather* they should not be touched for five days.

REINFORCED CONCRETE CHIMNEYS.

The following is an extract from a paper read before the Gloucestershire Engineering Society by Mr. J. S. E. de Vesian, M.Inst.C.E.—ED.

QUITE recently Messrs. Mouchel & Partners (the author's firm) designed a chimney at Nuneaton for the Griff Colliery Co., at their Clara Pit, and it is proposed to take that chimney as a basis for these remarks.

The Clara Pit commenced work about 19 years ago, when a brick shaft was erected 100 ft. high and 7 ft. internal diameter at the summit. This was sufficient until a year or two ago, when to cope with the extra haulage, the coal face being now some three miles from the shaft, new engines and boilers were put down.

As no extra chimney shaft was provided, it was necessary to burn a very much better quality coal, and it was not possible to make use of the pit slack as before.

Some five or six years ago the brick chimney began to lean over towards the engine-house, and as it was then found to be 4 ft. 6 in. out of plumb, it was decided to have it straightened. This was done by cutting a course of brick away and inserting steel wedges, and then gradually withdrawing these until the chimney regained its original vertical position.

MAKING THE BLOCKS FOR MONOSHAFT CHIMNEYS.

In the firebrick lining a course of unburnt firebricks were inserted, and as the chimney came up straight these squeezed out and brought the lining plumb up with the chimney.

At the present time this chimney is again more than 2 ft. 6 in. out of plumb in the same direction. These facts, together with the question of economy, were the chief reasons for the adoption of a Monoshaft chimney.

The Monoshaft chimney is only about one-third the weight of the brick shaft, and therefore the pressure on the ground is reduced very considerably. In view of the fact that the Monoshaft chimney is carried on a reinforced-concrete foundation slab, any uneven settlement would be bridged over by this slab. In addition to this, the shaft proper is reinforced in a very practical manner, and even if the movement did take place it would be a movement of the whole mass, and not of one particular part ; and it is, therefore, extremely unlikely that any crackling would occur as would be quite likely to happen to a brick shaft.

In a brick shaft the weight of the shaft and the strength of the mortar joints constitute the strength of the chimney, and as the strength in tension of mortar joints is very small, the weight is the only factor of stability.

It is usual to assume a wind pressure of 50 lbs. per sq. ft., equal to 100 miles per hour, and the width of base and weight of chimney must be such as to withstand this, with a suitable factor of safety, without putting any tension on the material at all.

In a Monoshaft chimney the steel reinforcement takes all the tension, so that the weight can be eliminated to a very great extent, and reduction in weight generally means a reduction in cost, although not in the same proportion in this case, as the steel used is bulk for bulk about ten times the cost of brickwork. However, as the steel required is only a very small proportion of the bulk, the prices of Monoshafts are usually much less than brickwork chimneys. Of course, it might just happen that the site of a chimney was very near to a cheap brickfield, and then prices would not compare so favourably, although at Nuneaton, where ordinary bricks could be bought at 18s., and special bricks for chimneys at 21s. delivered (per 1,000), the price of the Monoshaft chimney was less than for a brick shaft of similar dimensions.

Chimney at Nuneaton in course of construction.

It might be mentioned here that attempts have been made to build brick chimneys in cement mortar, but in no case has the result been successful, and often it has been necessary to take the chimney down owing to the development of large cracks.

The usual rate of building brickwork shafts is about 3 ft. a day, and in this height there would be over 4 in. of mortar in the joints, so that in three days there would be about 1 ft. of mortar. As this mortar would take much longer than three days to set, there is a danger of the work getting out of the perpendicular from that cause.

Experience has proved in all reinforced concrete work, that the insertion of steel in the concrete gives practically a new material, in fact an elastic stone, and all cracking tendencies are reduced to a minimum, whilst the cement mortar sets more rapidly.

In none of the chimneys (now over 100) erected by this new process has any crackling taken place in the reinforced concrete block work.

The contract for the Nuneaton shaft was signed on Saturday, June 25th, 1910. The following week was occupied in the preparation of the working details, and in setting out the site, and getting the timber and material required in the construction. The work was completed and put into use by August 25th. The dimensions of the shaft were the same as the former brick one before mentioned.

The special block used in this method of chimney construction—in place of the usual reinforced concrete method of shuttering and filling in in position—was devised by a Belgian engineer, M. Dumas, and has a claw-shaped socket at one end, this being the essential point. Each block is 10 in. deep, and of a width and length which can be varied for each particular shaft, care being taken in the designing to make them of such size that they shall not be unwieldy.

The internal part of the claw allows of the passage of the vertical reinforcement, thus securing a good bond; this socket is also of a sufficient width to allow the plain end of the next block to be inserted for a variable distance, thereby making it possible to reduce the diameter of successive courses, and effecting any desired taper to the shaft. In addition to this, the outside of the claws, coming at every external angle, forms an effective vertical rib, and gives a very good appearance to the shaft quite absent from brick chimneys. The space left in the sockets is filled up with a semi-dry concrete similar to the concrete of which the blocks are built, and this leaves the whole one solid mass the adhesion being perfect between one block and another.

Reinforced Concrete Chimney at Nuneaton.

The usual method of making the blocks on the Continent is to have a very large number of cast-iron moulds, sufficient to mould the number required for the day. These are filled with an ordinary wet mixture and left until set, and then the moulds are taken away and used again, leaving the blocks to mature until required for use.

At Nuneaton two moulds only were used, and as many as 80 blocks a day were made with them. This was accomplished by making the blocks with a semi-dry mixture and watering after the crust had set, in the same way as ordinary concrete building blocks are made, special care being taken with the moulds to have them of such a shape as would come away from the green concrete without breaking away any corners.

At the bottom of every triangle wood fillet is placed ; this, when taken out of the concrete, gives a groove to receive the horizontal reinforcement which is tied to the vertical by link steel. Every block has two longitudinal reinforcing bars in it to enable it to be handled without risk of injury.

The best description of a Monoshaft is to liken it to a split cane fishing-rod.

A splendid system of telescopic centering allows of the scaffold being removed every four or five courses, as may be desired, the only timber used being the flooring of the area of the chimney. Two sets of centres being used, which move alternately as the work proceeds, the timber is laid direct on to the telescopic centering.

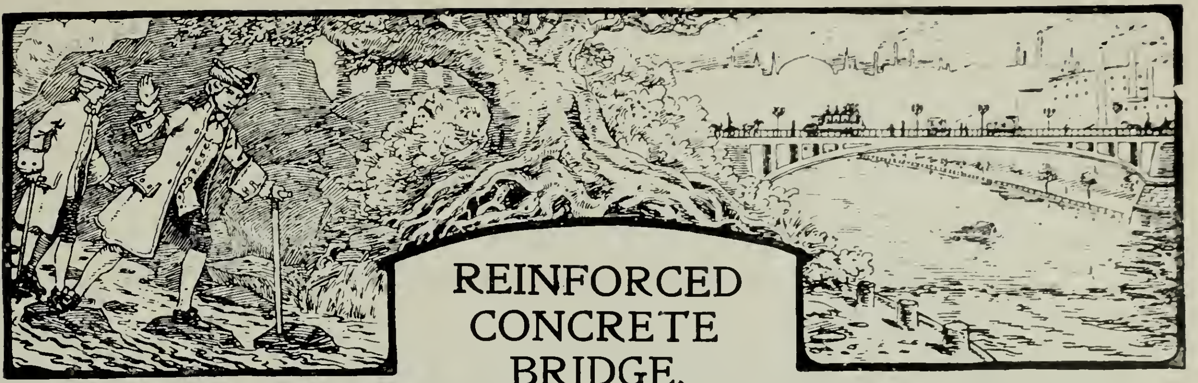
The blocks and mortar are wound up, either by hand or machinery, through a trap door in the scaffold.

The effect of high temperatures on concrete is very small, up to about 700° F. ; it appears to have a hardening effect.

1,300° F. is the heat registered at the summit of a 180-ft. Monoshaft at Haren, Brussels, and no damage in any way has been done to the structure, which was lined with firebrick for only 50 ft. It is usual to line with firebrick in the lower part of any chimney, and higher temperatures can be arranged for by increasing the height of this lining.

It will no doubt interest you to know that Monoshaft, Ltd., have constructed a chimney at Hanwell, near London, under the direction of P. C. H. Scott, a Gloucester engineer. One has also been built at Newcastle-on-Tyne for the Co-operative Wholesale Society.

The chimney for the Power Station at the Brussels Exhibition is to be removed at the termination of the Exhibition. This shaft is 230 ft. high, and experiments are being carried out to see what angle a Monoshaft could assume without breaking.



REINFORCED CONCRETE BRIDGE, MEADOW STREET, PITTSBURG, U.S.A.

By N. S. SPRAGUE, M.Am.Soc.C.E.

One of the finest examples of the use of reinforced concrete for arch bridges is in the Meadow Street Bridge, in Pittsburg, Pennsylvania, described below. We are indebted to "Engineering News" for the particulars of this work and also for the line drawings.—ED.

THE Meadow Street bridge is the largest reinforced concrete bridge in the vicinity of Pittsburg, and is the first bridge of its kind built by the City. For this and æsthetic reasons special consideration was given to such artistic features of the bridge as were possible, without materially increasing the cost of the structure, in order to give the bridge a pleasing appearance.

The plans provide for a reinforced concrete arch bridge 454 ft. in length, having a 30 ft. roadway and two 10-ft. footpaths, with a maximum clear height at the centre of the arch of 78 ft. The length of the main arch span is 209 ft., with a rise of 46·14 ft., and consists of three arch ribs, the two outside ribs being uniformly 3 ft. 9 in. in thickness and the central rib 5 ft., and all three ribs having a depth varying from 5 ft. at the crown to 6 ft. 2 in. at the springing line. The profile of the slopes and the location of proposed streets in the valley determined the length of this span.

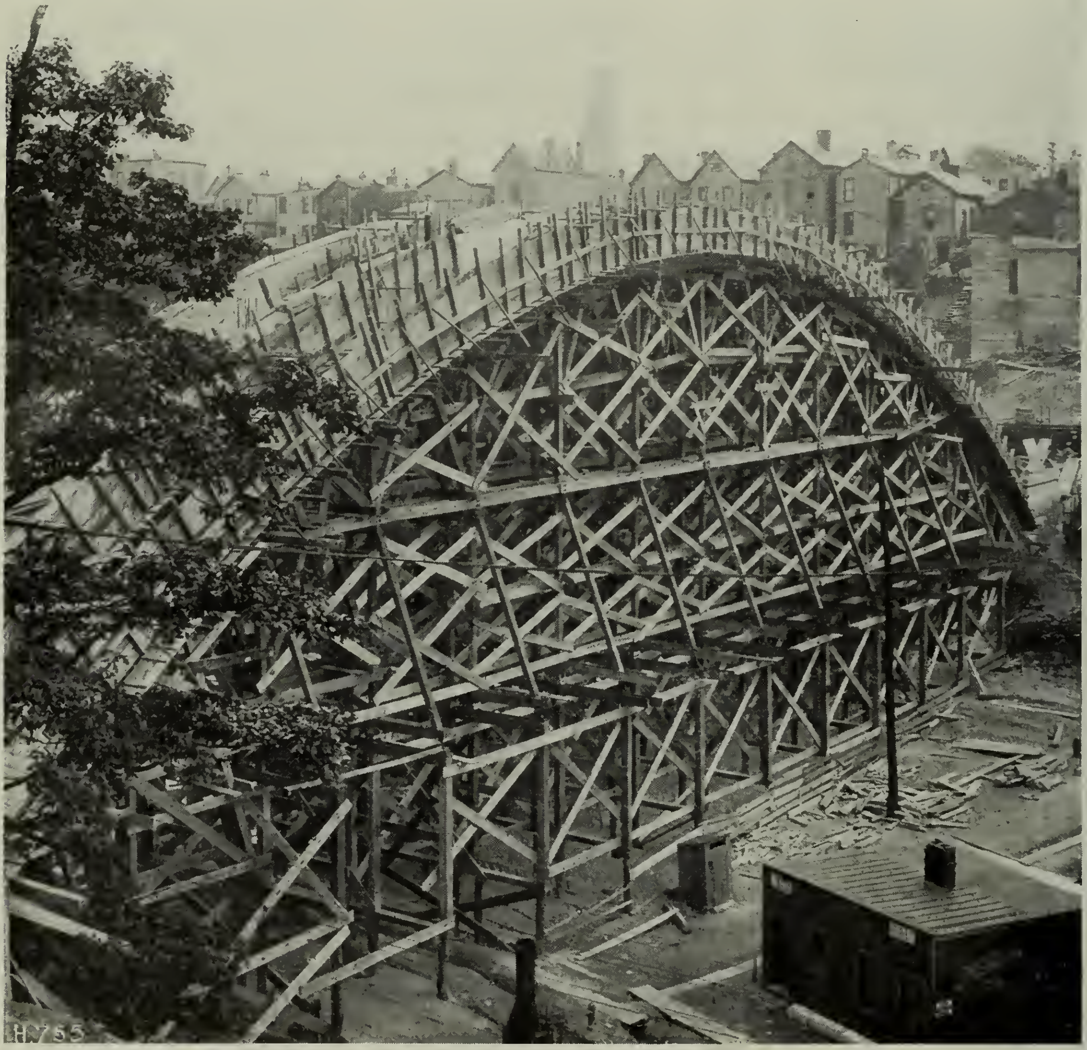
The main arch ribs are connected at the panel points by 26 horizontal struts, each 12 in. in width. The depth of these struts is the same as the arch ribs, except near the crown of the arch. These struts are to provide additional lateral strength, against wind pressure and possible indeterminate secondary stresses. The main arch ribs spring from two main piers of cellular construction 37 ft. 9 in. long and 14 ft. in width.

Between the main piers and the abutments are three viaduct approach arches, each having a span of 21 ft. Calculations were made for two arch spans between these points, but it was found desirable to reduce the arch thrust at the top of the main pier as much as possible. For this and æsthetic reasons, and also from the standpoint of economy, three spans were decided upon and adopted.

The abutments are U-shaped, of cellular construction, the horizontal thrust from the approach arches being transmitted from the face wall of the east abutment by partition walls extending from the face to a point where the line of pressure intersects the rock surface. At the east abutment the thrust from the approach arches is transmitted to the face wall, which is reinforced by a buttress at the back of each main arch rib. The front and side walls of the east abutment are 13 in. in thickness and are designed for vertical pressure and also to act as a beam if necessary, the top of the walls being covered and tied together with a reinforced-concrete slab, varying in thickness from 8½ in. at the centre line of bridge to 12¼ in. at the curb lines, similar to the type used on the main spans, and extending 28 ft. back from the face of the abutment. Beyond this point the side walls are designed as ordinary retaining walls with spread footings and to act as cantilevers.

The side walls on the west abutment are 37 ft. in length and designed as ordinary retaining walls, the same as the portion of the side walls of the east abutment mentioned above.

The roadway of the bridge, which is of reinforced concrete slab and floor beam construction, is supported on spandril girders supported by columns 24 by 24 in., spaced 15 ft. centre to centre, resting upon the main arch ribs. The roadway on the approach spans is supported in a similar manner except the span is 21 ft., and the columns, which are 24 by 36 in., extend to the rock below, the greatest length of the columns of the approach spans being 39 ft. and on the main span 29 ft. in length.



View of bridge during construction.

Reinforced Concrete Bridge, Meadow Street, Pittsburg, U.S.A.

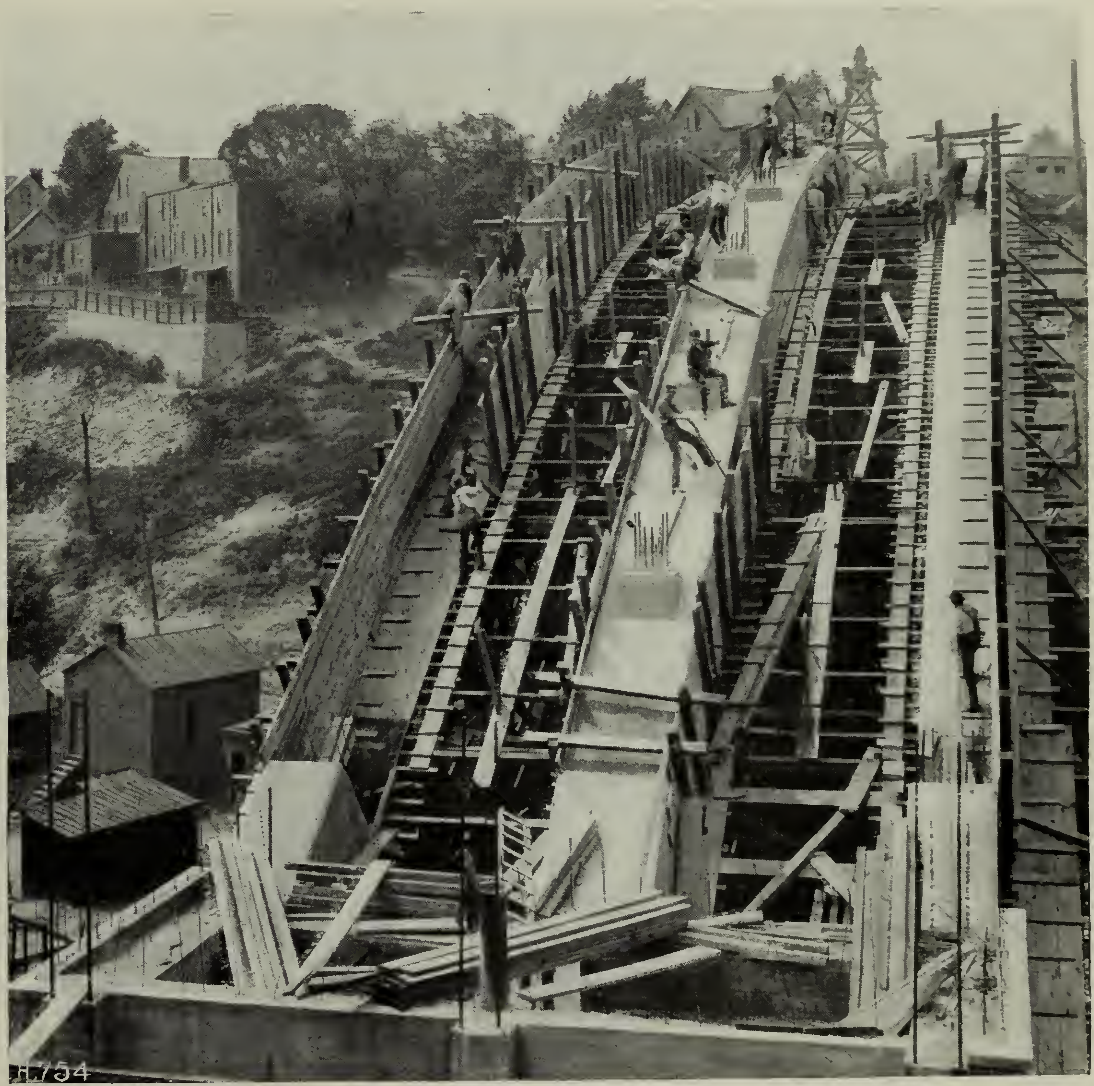
The footpaths, which are reinforced, have a uniform thickness of 6 in., with a slope of $\frac{1}{4}$ in. to the foot to provide drainage, are 10 ft. in width and are supported on beams acting as cantilevers spaced 7 ft. 6 in. on the main span and 7 ft. on the approach spans.

Substantial concrete railing posts are provided on both the approaches and the main span, having the same spacing as the columns. Between these railing posts will be placed, under a subsequent contract, an iron bridge railing of appropriate design.

The bridge is lighted by four ornamental lamps placed on the curb lines opposite each main pier.

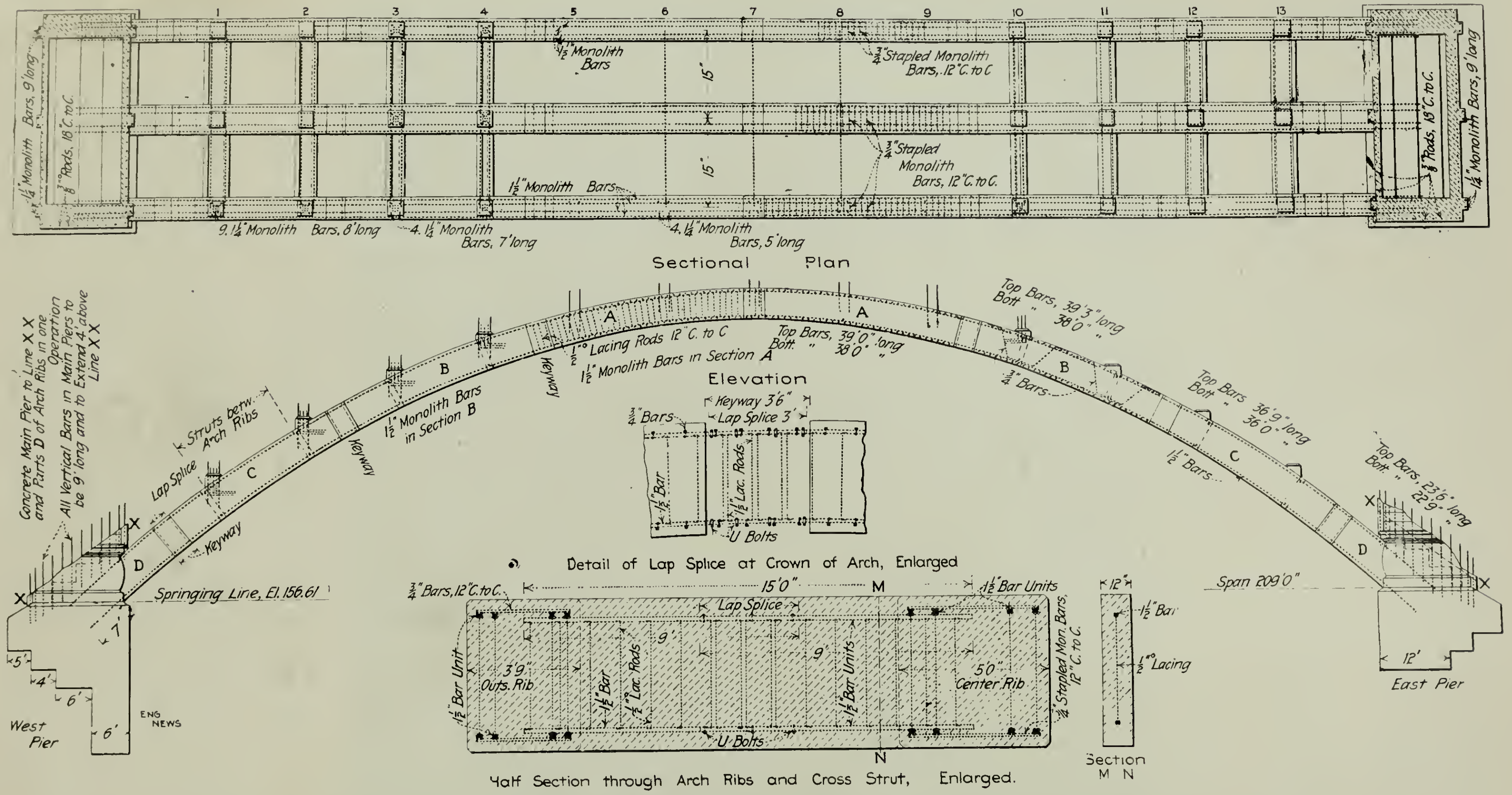
REINFORCEMENT.

An efficient, economical and practical type of reinforcement for the main arch ribs was found more difficult to design, without infringement upon patent rights, than the arch itself. After considerable study the effort was abandoned and fabricated units or steel skeleton were shown on the plans, the contractor having the privilege of substituting any other approved form of reinforcement. The Monolith bar, manufactured by the Monolith Steel Co., type of reinforcement was used for the entire work on the bridge. The reinforcement is open hearth medium steel complying with the requirements recommended by the American Railway Engineering and Maintenance of Way Association.



Depositing concrete in the arch-ribs.
Reinforced Concrete Bridge, Meadow Street, Pittsburg, U.S.A.

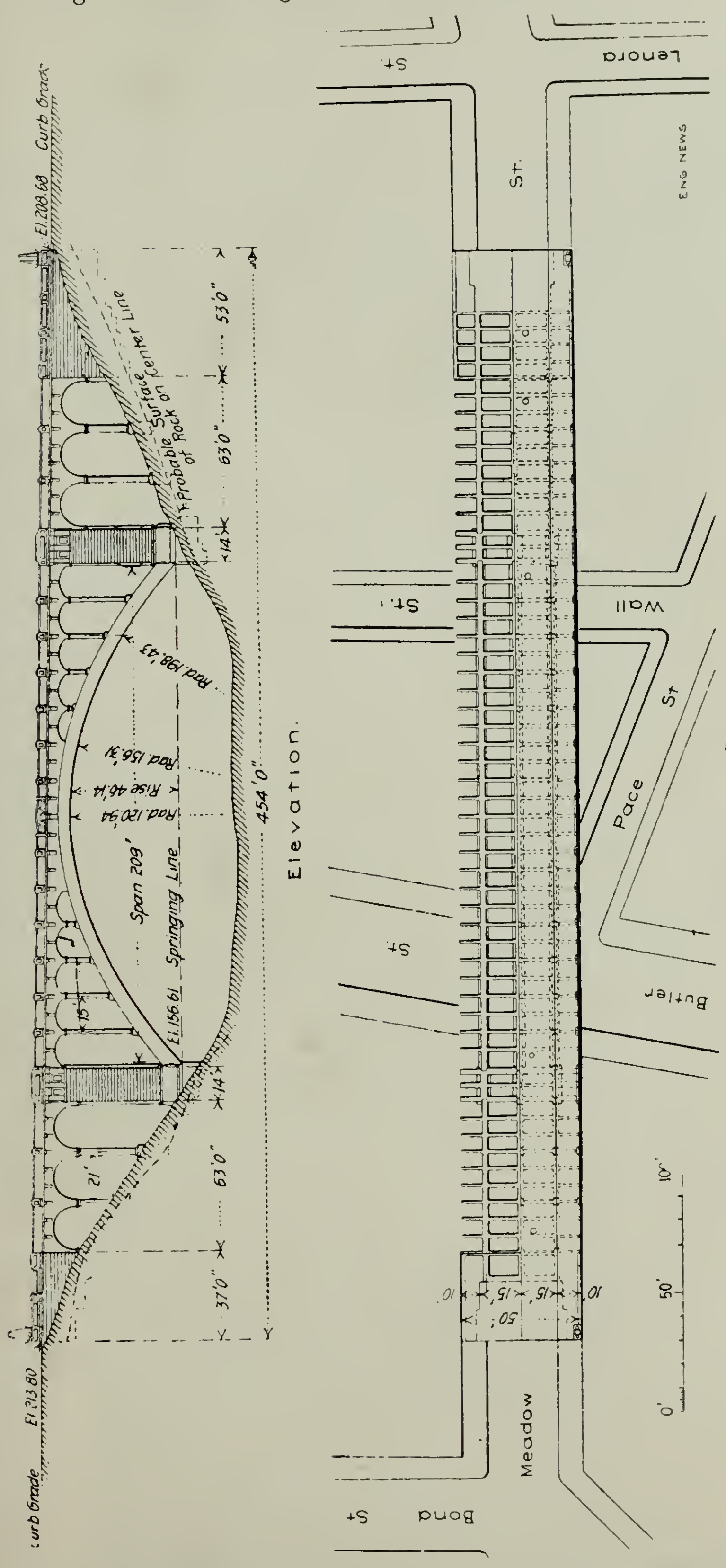
The reinforcement for the main arch ribs consists of eight 1½-in. grooved bars,


1
2
3
4
5
6
7
8
9
10
11
12
13
1¼" Monolith Bars, 9' long
⅜" Rods, 18" C. to C.
½" Monolith Bars
15'
¾" Stapled Monolith Bars, 12" C. to C
¾" Stapled Monolith Bars, 12" C. to C.
1½" Monolith Bars
9. 1¼" Monolith Bars, 8' long
4. 1¼" Monolith Bars, 7' long
4. 1¼" Monolith Bars, 5' long
Sectional Plan
Top Bars, 39'3" long
Bott. " 38'0" "
Top Bars, 39'0" long
Bott. " 38'0" "
Top Bars 36'9" long
Bott. " 36'0" "
Top Bars, 23'6" long
Bott. " 22'9" "
A
B
C
D
X
½" Lacing Rods 12" C. to C
1½" Monolith Bars in Section A
1½" Monolith Bars in Section B
¾" Bars
1½" Bars
Keyway
Lap Splice
Struts betw. Arch Ribs
Concrete Main Pier to Line X X and Parts D of Arch Ribs in one Operation
All Vertical Bars in Main Piers to be 9' long and to Extend 4' above Line X X
Springing Line, El. 156.61
Span 209'0"
7'
5'
4'
6'
6'
12'
West Pier
East Pier
ENG NEWS
Elevation
Keyway 3'6"
Lap Splice 3'
1½" Bar
1½" Lac. Rods
U Bolts
Detail of Lap Splice at Crown of Arch, Enlarged
¾" Bars, 12" C. to C.
15'0"
M
N
1½" Bar Units
1½" Bar Unit
3'9" Outs. Rib
5'0" Center Rib
9'
½" Lac. Rods
¾" Stapled Mon. Bars, 12" C. to C.
12"
1½" Bar
½" Lacing
Section M N
Half Section through Arch Ribs and Cross Strut, Enlarged.

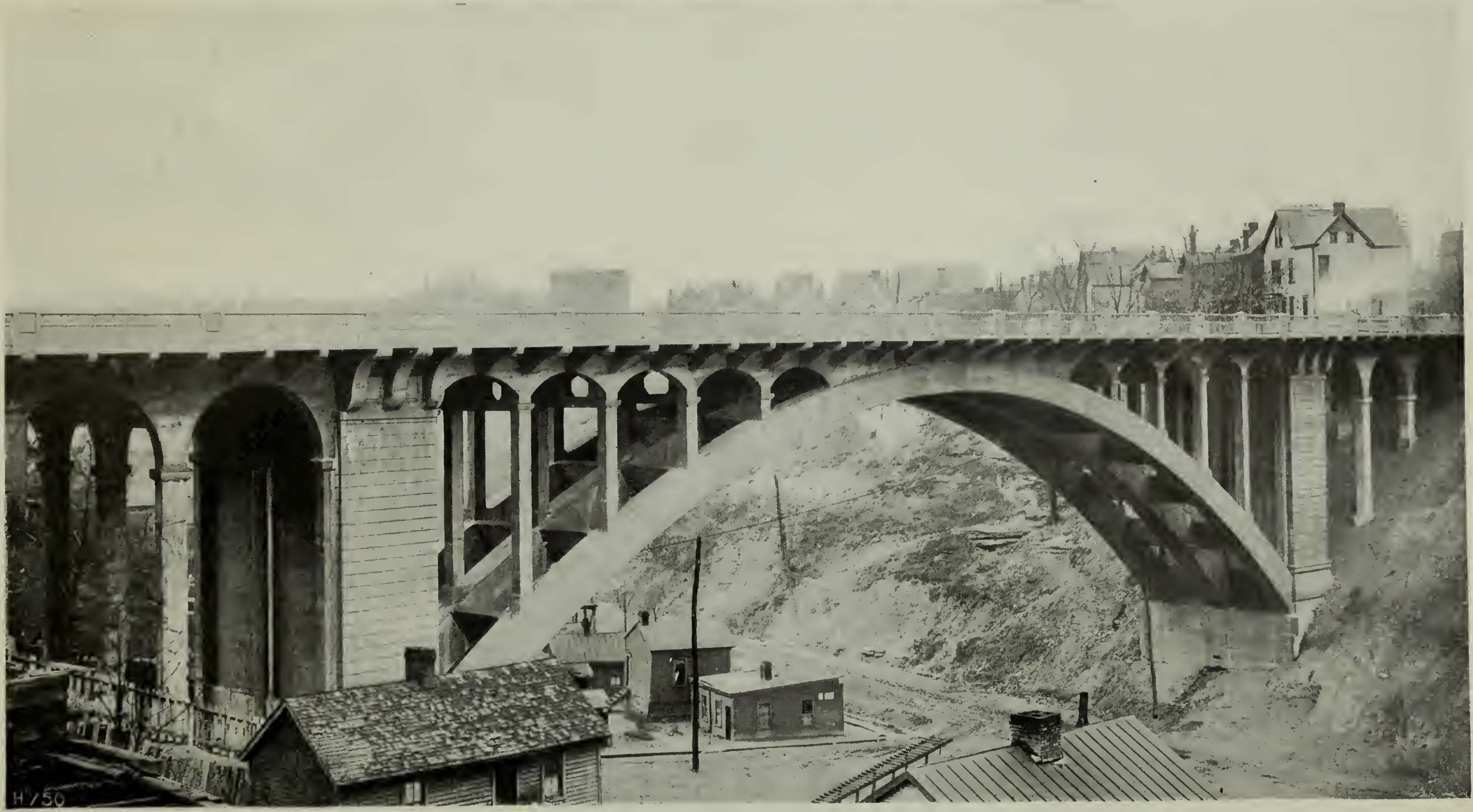
Detail of the 209 ft. Span.

Reinforced Concrete Bridge, Meadow Street, Pittsburg, U.S.A.

arranged in four pairs, each pair connected with ½-in. lacing bars, clamped into the grooves on the 1½-in. bars, and spaced about 1 ft. apart, making a latticed girder effect, placed vertically and curved to fit the arch rib. The top and bottom bars were kept about 4 in. from the upper and lower surfaces of the concrete. The latticed girders were placed in pairs on each side of the rib, then transversely across the upper and lower bars of the latticed girders were placed stapled bars of the length sufficient to include the outside girders. The staples were then clamped around the longitudinal bars of the girder, so as to hold them accurately in their places, forming a box girder effect and acting as lateral stiffeners to the rib. All of the reinforcement was set in place and wired to the forms before concreting. The longitudinal bars of the latticed girders were made long enough to lap past each other in the key, a sufficient distance to be U-bolted together, strong enough to develop the strength of the bars. After the various sections of the rib were cast, the U-bolts were securely tightened up and the keys concreted, the idea being to avoid initial stresses in the steel coming from the settlement of the forms on account of the load of the ribs. The strut reinforcement, which was made in two pieces of latticed girder frames, similar to that of the ribs,



Reinforced Concrete Bridge, Meadow Street, Pittsburg, U.S.A.



Span, 209 ft.
Reinforced Concrete Bridge, Meadow Street, Pittsburg, U.S.A.

was stapled to the longitudinal bars in the main ribs, the struts being placed at panel points on the bridge, the main bars being 1½ in. The pieces were lapped past each other in the middle of the struts and U-bolted after concreting and keying the ribs strong enough to develop the bars. The struts were then concreted.

Where the column bases joined the ribs, shear reinforcement was placed in the ribs to take care of the secondary stresses owing to the concentrated load of the columns, and bars passed from the rib into the column base to carry the component of the column load passed along the rib axis. The column reinforcement is 1¼-in. vertical bars, stapled at 9 in. intervals and clamped around the hooped bands, which were 1¼ in. rounds.

The spandril girders which were built above each arch rib, spanning from column to column on 15-ft. centres, were reinforced with 5 1½-in. bars, laid horizontally, and 2 1½-in. bars curved to fit the soffit of the arch. Top reinforcement was placed over the columns, although the spandril girders were designed as simply supported.

The floor beams were supported by spandril girders, having a span of 15 ft. centre to centre crosswise of the bridge. The floor beams were reinforced with 4 1¼-in. bars and 1 1-in. bar, grooved as before, negative reinforcement being placed over the centre column.

The reinforcement in the roadway floor slabs is ¾-in. grooved bars, spaced 6 in. apart, centre to centre, on a span of 7 ft. 6 in., centre to centre, between the floor beams in a slab of minimum thickness of 8½ in.

The reinforcement for the footpath slab is ⅝-in. grooved bars, placed 6 in., centre to centre, in a 6-in. slab of 7 ft. 6 in. span, between footpath brackets. The reinforcement for the floor system was set in place and wired to the forms before concreting.

Round bars were used in the piers at the end of the main span near the surface of the concrete, to prevent cracking of the thin walls. The reinforcement was ⅜-in. round rods spaced 24 in. apart and wired in place.

The specifications for cement were drawn in accordance with the standards prescribed for this material by the Committee on Uniform Tests of Cement of the American Society of Civil Engineers. The main arch ribs, spandril columns, spandril arches, approach arches, floor system, parapets and railing posts are made of concrete, mixed in the proportions of 1 : 2 : 4. The concrete for the main piers, approach columns and abutments is mixed in the proportion of 1 : 2½ : 5. Broken stone, evenly graded from ¼ in to 2½ in. in diameter, is specified for the main arch ribs, and gravel ranging in size from ¼ in. to 1½ in. is required for all other construction.

DESIGN.

The main span is a five-centred arch approaching very closely to a parabola. The spandril girders are designed to act as beams, the object being to provide for expansion at the main piers. On the approach spans the arches are designed for arch action under the dead load and to act as cantilevers under the live load. Expansion joints are provided for the roadway construction at the main piers and abutments.

The following assumptions for loading were made :—*Dead load :* Concrete, including reinforcement, 150 lb. per cu. ft. ; asphalt pavement, including 6-in. concrete foundation, filling of gravel under the pavement and street car track construction complete, 140 lb. per cu. ft. *Live load :* A street car, weighing 35 tons, was used in the design of that portion of the roadway covered by tracks. A uniform load of 100 lb. per sq. ft. was used over the balance of the roadway and 60 lb. per sq. ft. on the footpaths.

The working stresses used in designing the bridge were as follows :—Tension : Steel in floor slabs and main arch ribs, 12,000 lb. per sq. in. ; steel in beams and girders, 15,000 lb. per sq. in. *Compression :* Concrete for local members, 600 lb. per sq. in. ; concrete for main arch ribs, 500 lb. per sq. in.

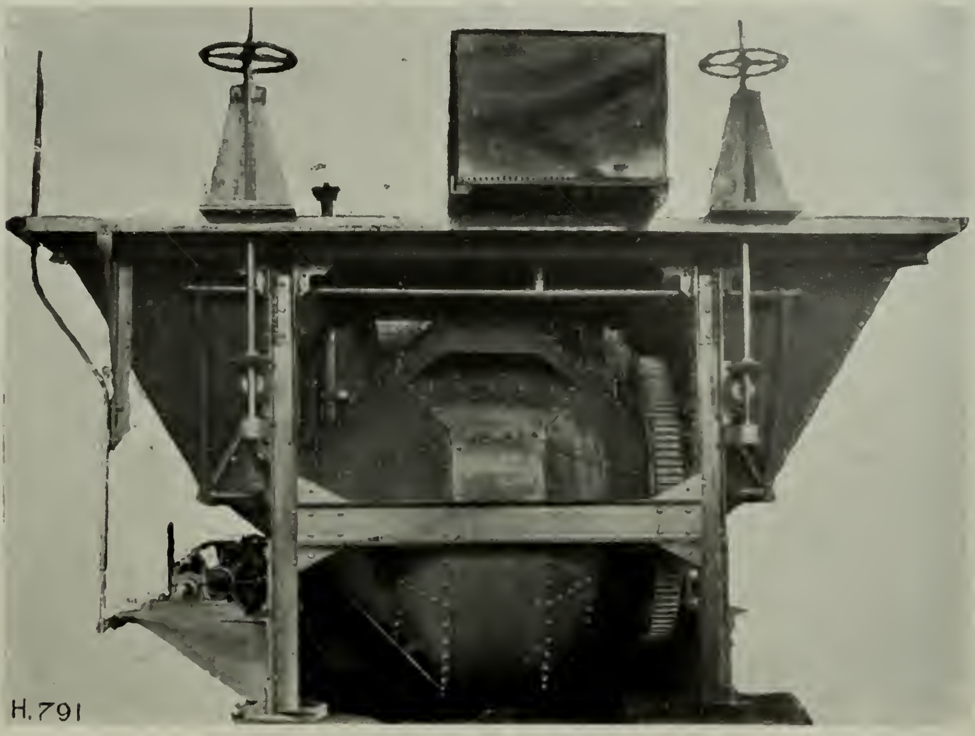
The contractors for this work were the Friday Contracting Co., of Pittsburg, U.S.A.

CONCRETE MIXERS.

In some former issues we published articles on the different appliances for concrete making, and we now intend giving a further series of articles on additional concrete mixers.—ED.

CONCRETE mixers may be divided roughly into two main divisions : (1) continuous mixers, in which the material is continuously fed and issued from the machine ; and (2) batch mixers, in which a certain quantity of concrete is fed and mixed and then discharged as a batch. There are advocates for both types of machine, and certainly, if operated correctly, both can do excellent work.

We illustrate in this article a batch mixer of a rather different type, in that an endeavour is made to construct a mixer which was to be used as a batch mixer and could not be used continuously, the contention being that this is a necessary precaution, because, if the material is fed into one side of the mixer and out of the other, it may not be turned a sufficient number of times to secure proper mixing. Generally, it may be remarked that this mixer is fed with the materials while revolving in the mixing direction and must be reversed in order to discharge the



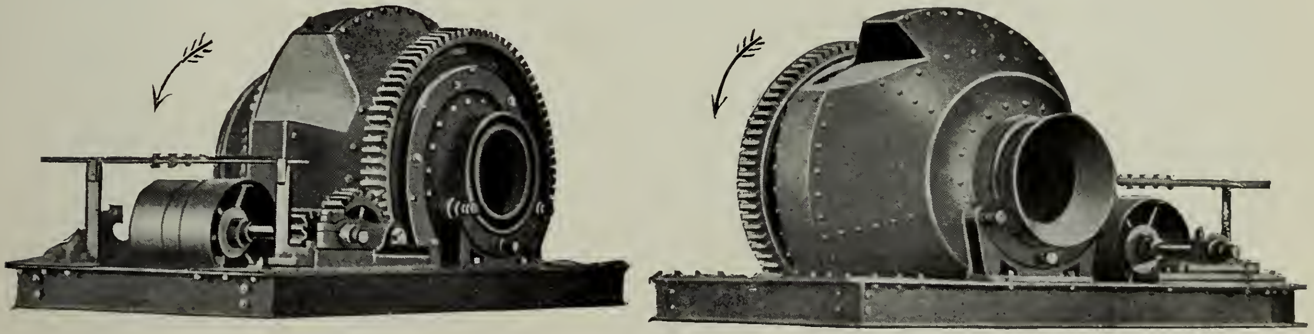
BARKER & HUNTER'S REVERSIBLE CONCRETE MIXER.

mixed concrete. It is a new type of machine made by a firm of manufacturers who have built concrete mixers for a great many years past.

BARKER & HUNTER'S PATENT REVERSIBLE CONCRETE MIXER.

THE mixer consists of two truncated cones, the bases of which merge into a cylinder. The ends of the cones are mounted with roller path bearings and rotate on rollers mounted on a suitable frame. In the largest circumference of the cone there are openings from which to discharge the mixed materials; at each of these openings there is an overlapping plate, so that there is no direct opening on a radial line, but each opening is in a circumferential direction. The materials are mixed as the cone rotates in the one direction, and discharged when the cone rotates in the other direction; the machine is therefore a compulsory batch mixer, as the operations of filling and discharging cannot be performed simultaneously. The cone is rotated in both directions by spur gearing.

The mixer is fitted with two hoppers, and can be charged with materials from either or both ends, which are always open, with the cone either stationary or in motion. The cone is run at 12 to 15 revolutions per min., and each revolution ensures 4 complete turnings of the materials in the cone. The cone empties itself in 2 revolutions when it is run in the reverse direction and will deliver into a truck, skip or trench.



Mixing. Discharging.

BARKER & HUNTER'S REVERSIBLE CONCRETE MIXER.

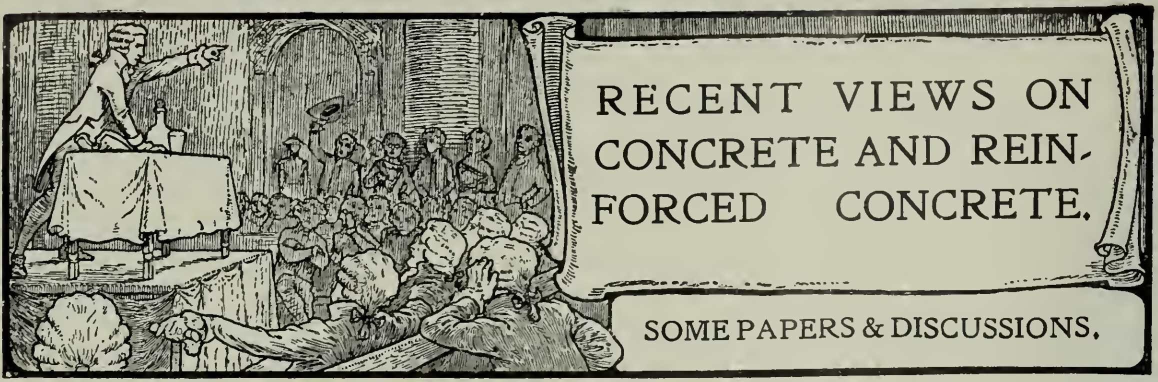
The time required for mixing a batch in either size is about 90 seconds—viz.:

	Seconds.
To charge materials into cone	20
To mix completely	60
To discharge	10
	90

or 40 batches per hour.

On a contract now in progress an output of 300 cu. yds. per day of 10 hours has been quite easily maintained with a 1 cu. yd. machine, the hoppers in this instance being 25 ft. from the ground level and all the charging done with a steam crane, not the most favourable conditions for a maximum output.

The smaller machines, $\frac{1}{5}$ and $\frac{1}{3}$ cu. yd. size, are driven by two belts, one open and the other crossed, and in this manner the cone can be run in the mixing direction and reversed for discharging, and the concrete, when made, delivered into a barrow or skip thoroughly mixed and uniform in quality and in the small quantities suitable for reinforced concrete work.


RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.
SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

THE DISSOCIATION OF COMPETITIVE DESIGNS AND TENDERS

Paper by R. W. VAWDREY, B.A., Assoc.M.Inst.C.E.

The following is an abstract of a paper under the above title which was read by Mr. R. W. Vawdrey at the meeting of the Concrete Institute held on February 2nd, 1911, *Mr. Alexander Ross, M.Inst.C.E. (Vice-President), in the chair.*

It was, said the author, continually being forced upon the notice of all those engaged in designing in reinforced concrete that the condition of the industry at the present time was very far from being such that the best work in design was the most successful or the most remunerative ; in fact, he went so far as to say that a very considerable premium was placed on slovenly or reckless work as compared with conscientious, careful, and well-thought-out designing. He proposed, therefore, to deal with the subject in the following order :

(1) The description of the existing conditions.
(2) The causes which have led up to them.
(3) What he believed to be the remedy.

He commenced by giving a few typical examples of what he considered unsatisfactory competition.

From these it was seen that the specialist had usually to undertake the following work free of charge, and, moreover, to do it at the same time that a large number of his competitors were doing exactly the same thing.

(1) To prepare preliminary designs for the structure in accordance with the general conditions required by the engineer or architect in charge of the work. This often necessitated the specialist's obtaining information as to the site, nature of foundations, etc., at his own expense.

(2) To prepare lists of quantities upon which contractors can tender, and to be financially responsible for the accuracy of these quantities—*i.e.*, be prepared to pay the value of any omissions which may occur. He had also to accept financial responsibility for the stability of the structure.

To the first of these items in itself there was, of course, no objection, as it is the work for which a specialist exists, though all the necessary information as to the site, etc., ought clearly to be supplied by the engineer or architect. The grievance lay in the fact that the specialist should be asked to do it for nothing, and at the same time that a large number of his competitors were doing the same thing. Given certain conditions, any number of equally competent and experienced designers would generally arrive at more or less the same result. The design, therefore, frequently gained very little by such competition, while the designers lost a great deal.

The second requirement, however—*i.e.*, the preparation and guaranteeing of quantities at a preliminary stage of the work—was most objectionable, and was due entirely to the necessity, when the present methods were adopted, of enabling contractors to tender in competition before any particular design had been chosen.

It was no doubt often advantageous from the point of view of the prospective owner of a structure that he should be able to invite competition in design as well as in price. Yet it was comparatively seldom that architects were asked to prepare competitive designs for any but large and important public buildings, and, so far as he was aware, to invite tenders for the construction of a building which had not yet been designed was absolutely unheard of when any material other than reinforced concrete was being considered. The most that was required in such cases, even when competitive designs were invited, was for an architect to produce his scheme as a whole, on the understanding that the successful competitor would be subsequently employed to carry out the work, or that the successful design might be purchased at a fixed price.

But the case of the reinforced concrete specialist was far different. He was invited not only to prepare a design, but to do so in sufficient detail to enable a number of contractors to tender for its construction, and it was for this purpose that it was usually necessary, in addition to the preparation of the design, to issue complete quantities. This was detailed work which ought not to be done until after the adoption of a particular design, and which should be paid for by the client, as it would be in almost any other circumstances.

The specialist's grievance, however, did not end here. He was not only required to prepare quantities, but was also compelled to make himself financially responsible for the accuracy of his quantities and for the stability of the structure. An individual engineer or architect, designing under ordinary circumstances, was, of course, responsible for the accuracy of the quantities or designs which he produced ; but unless he could be convicted of culpable negligence, it would be unheard of to compel him to pay the contractor who might subsequently carry out the work for any portion which was not included in the quantities issued by him.

CAUSE OF THE ABUSES.

We now come to the reason why this unsatisfactory state of affairs existed to a far greater extent in reinforced concrete than in other classes of engineering or architectural work, such as steelwork, brickwork, masonry, etc. Briefly, it appears to be twofold : First, because reinforced concrete was of far more varied and general application than the other materials mentioned ; and, secondly, because it was far more intricate in design.

A reinforced structure has to be designed not only externally, but internally. The calculation of external dimensions of a beam formed only a small portion of the whole amount of designing which was required. It was the quantity and arrangement of the steel in the inside of the beam which formed the crux of the question. And for this reason the design of a reinforced concrete structure might be more nearly compared to the design of a piece of machinery than, let us say, to that of a masonry retaining wall.

Reinforced concrete differed entirely from anything that had preceded it. It was not a machine which could be manufactured and sold by those who have made a special study of it, nor was it a material the knowledge of which was simple and practically universal. It could, however, and eventually must be, used by almost all classes of engineers and architects ; yet, unlike any other material of general application, its scientific use necessitated an amount of attentive study, and, above all, of practice, which could only be obtained by one who specialises in the subject.

The ordinary constructional engineer or architect must therefore reconcile himself to the necessity of consulting a specialist if he wished to use the material in the best possible manner. The author supposed it was hardly necessary to say that in the use of the word " specialist " there was no intention to differentiate between an individual engineer and a commercial firm. The word was intended to include any man or firm who had given special attention to, and had a large amount of experience in, the design of reinforced concrete.

The Remedy.—It was the underlying objection to the necessity for a specialist which had led to the confusion of the specialist designer with the contractor. This was, in his opinion, the root of the evil, and the remedy appeared to be in a dissociation of competition in design and competition in price. These were now almost invariably combined in one.

If this combination could be avoided he was convinced that it would be the better for the specialist designers, the architect, or engineer, and the owners of reinforced concrete structures alike.

No doubt there might be many ways of obtaining the desired results, but the procedure which the author advocated was as follows :

When it was decided that a particular structure should be carried out in reinforced concrete, in all ordinary cases one reliable specialist firm, and one only, should be asked to prepare preliminary designs and an estimate of cost, on the understanding that if that appeared satisfactory that firm should be employed to prepare complete working drawings for a definite fee, previously arranged, just as such drawings would be prepared by the engineer or architect himself, if the material were brick or masonry, or mass concrete, for which no specialist is necessary. When these drawings had been made and approved, and not before, tenders for the constructon of the work should be invited from contractors.

But just as on certain occasions it might be desirable to invite competitive designs for, let us say, an important masonry bridge, so it might be in the case of a concrete structure, and a few firms should then be invited to prepare designs in competition.

Where designs were invited in competition, a sum should be provided for payment to the unsuccessful competitors, as was frequently done in architectural competitions.

Discussion ensued, in which the following took part : Messrs. C. F. Marsh, M.Inst.C.E., G. C. Workman, C. H. Colson, M.Inst.C.E., G. Corderoy, F.S.I., W. A. Haskins, L. Serraillier, T. B. Shore, E. F. Etchells, E. P. Wells, J.P., and Alexander Ross, M.Inst.C.E.

THE JUNIOR INSTITUTION OF ENGINEERS.

THE ARCHITECTURAL AND ENGINEERING FEATURES OF THE ROYAL AUTOMOBILE CLUB BUILDING.

Paper by S. BYLANDER (Vice-Chairman J.I.E.)

The following is an abstract of a paper read by Mr. S. Bylander before the Junior Institution of Engineers on February 24th, 1911.

ARCHITECTURAL FEATURES : PLANNING AND DECORATION.

THE new building for the Royal Automobile Club occupies a portion of the site of the old War Office, with a frontage of 228 ft. west of the well-known Carlton Club. The façade to Pall Mall has been treated in the style of Louis XIV. The main entrance in the centre is well marked by being placed under a boldly projecting colonnade or portico and sculptured pediment. This colonnade is formed of detached Ionic columns. Similar columns, but three-quarter ones, have been introduced on either side of the portico, and the façade is finished at the east and west ends by minor entrances accentuated by the architectural treatment above. The ground floor storey has deeply recessed semi-circular headed windows, and, being well rusticated, looks capable of supporting the superstructure.

The main cornice, as well as part of the parapet, in accordance with the conditions of the Crown lease, had to line with those of the Carlton Club, which condition to a certain extent determined the proportions of the façade, inasmuch as the club required three storeys between the entablature and the ground floor level.

It may be of interest to architects to mention that the lease stipulated that no part of the building, except the portico and chimneys, should project above a certain defined line inclined to the horizontal over the street—*i.e.*, a line drawn from a point on the building on the opposite side of the street, 5 ft. 6 in. above the pavement level, through the nib of the coping to the parapet.

The façade at the back overlooking Carlton Gardens has been treated in the same style, but is of a simpler nature, no carving being introduced and pilasters being used instead of columns. Both of the façades have been faced with Portland stone ; the roof is covered with green Westmorland slates, and the dressings are in copper.

On passing through the fine wrought iron main entrance gates, one is immediately in the entrance hall ; the architectural effect from this point is very striking. To the left and right (east and west) are steps leading to the reception room and strangers' room respectively. The former has folding doors opening into the restaurant on the same floor. The latter opens on to the smoking room.

On the axis of the main entrance and entrance hall, a wide flight of steps leads to a magnificent two-storey elliptical vestibule, the upper portion being treated with the Roman Doric order and a large coved ceiling, in the centre of which is a horizontal wrought iron ceiling light, giving excellent light to this portion of the building. The central pair of folding doors to the great gallery at the back is also on the axis of the main entrance, which is the minor axis of the elliptical vestibule. On the major axis of this vestibule and east and west of the same are well proportioned corridors, at the ends of which are the main doors of the restaurant and club room.

The two electric passenger lifts have been formed in elliptical lobbies, which, as well as the main staircase and post office, are reached through one or the other of the various openings around the vestibule. Service and cloak rooms have been formed off the said corridors leading to the restaurant and club room. The great gallery is a two-storey room, and has a balcony and platform.

It should be noted that the building is planned on the French axial system, which not only lends itself to a fine monumental treatment as regards decoration, but also adapts itself with special advantage to a steel frame construction, on account of regularity and repetition of dimensions and details.

On the first floor is the members' dining room, being of the same size as the restaurant on the ground floor ; in the style of William Chambers. This floor also contains a billiard room, card room, committee rooms, library, etc.

The chief feature of the second floor is a fine Georgian room opening on to the terrace overlooking Carlton Gardens, St. James' Park, which forms the roof of the great gallery. This floor is used chiefly for club offices ; a few members' bedrooms have also been provided.

The third and fourth floors are solely given up to members' bedrooms, and the fifth floor, which is built at the rear of the building only, in accordance with the conditions of the lease, has been planned as servants' quarters, with the exception of a portion next to the main staircase, which is set apart for a photographic studio. There are in all over a hundred bedrooms. Some small suites have been provided consisting of a sitting room, bedroom, and bath-room, each having its own front door.

Descending to the entrance hall on the ground floor, access is obtained by the two-way staircase to the lower ground floor and basement. The east portion of the former is entirely devoted to kitchen and kitchen services, whilst in the west portion the main cloak room and lavatories are placed.

A wide corridor leads to a gallery overlooking the swimming bath, fencing room, and racquets courts.

The chief features of the basement floor are the vestibule, swimming bath, and Turkish bath, in which the Greek style of architecture has been adopted. This floor also contains a fencing room, three racquets courts. as well as private bath and dressing rooms, etc.

ENGINEERING FEATURES.

It would hardly occur to the casual observer of the finished building that within its monumental walls were hidden nearly 2,000 tons of constructional steelwork, constituting the skeleton or frame upon which the walls and floors are supported, but, as a matter of fact, not even the solid looking front wall is self-supporting. The inside portions of most of the piers are hollow, the space being used for ventilation ducts, pipes, cables, etc., all the interior walls being as thin as possible and carried at every floor level on the steel frame.

The skeleton frame or cage construction was adopted as far as was consistent with economy, and in conformity with the London Building Act before it was amended.

The dimensions of the site are : Length, 228 ft. ; average depth, 148 ft. ; the height of the building being eight storeys above the basement floor, with the addition in parts of two mezzanine floors.

Several girders were required to span over large rooms 40 ft. wide, and to carry about 350 tons each. The weight of such girders varied from 15 tons to 24 tons. Special devices for making, handling, and erecting had to be arranged.

The chief engineering considerations in the design were sound construction, stability, rigidity, and fireproof qualities. The entire structure has been designed with a factor of safety of four (based upon the breaking strength of steel), now a standard in good engineering practice.

Economy was carefully studied, preliminary drawings and calculations being made to ascertain the cheapest and best type of construction, consistent with the architectural requirements. Every piece of steelwork was carefully made to the exact strength required in acordance with calculations, in order to avoid any waste of material, and it may be added that the design and calculations throughout were made with the greatest care and accuracy.

The setting out and spacing of the columns and main girders were primarily dependent on the architectural design. The building was designed on the axial system, where any axis is parallel with or at right angles to the main front building line, the centre lines of columns being parallel with the front building line, or perpendicular thereto. Simplicity and regularity in planning is of great advantage in steel frame construction, whilst irregular planning considerably increases cost and time of erection.

The preparation of the steel and architectural plans proceeded in the following stages :

(1) Skeleton plan on which the general design was defined, including size of rooms, position of walls, general requirements as to kind of ceiling and heights of rooms, and positions of stairs ; on the corresponding steel plans were shown the positions of columns and main girders, and their approximate size.

(2) Skeleton set, giving dimensions of centres of columns ; positions of walls, accurate to scale with their thickness dimensioned ; position of partitions ; levels of floors and staircase landings ; openings in floors ; size of principal ducts and shafts ; kind of material of exterior walls and partitions ; also typical details and spandril sections. From these drawings framing plans and schedules of columns were made. All columns, girders, and beams were shown and sections given ; typical steel details and spandril sections were made sufficient to illustrate the design.

(3) Working drawings :—These, containing further modifications and improvements of the skeleton set of drawings, are completely dimensioned, and accompanied by all details including sub-contractors' work. The working drawings for the steelwork were prepared as the work proceeded, and every detail was carefully studied to ascertain if any improvement could be made with due regard to the internal decorations, stonework, floor construction, ventilation scheme, plumbing, etc.

Detail drawings of steel in relation to stonework and decoration work were made to illustrate the construction required.

(4) The shop details and steel order lists were then prepared from the working steel plans.

Calculations.—Two sets of calculations were made for the steelwork, one approximate in connection with the skeleton plans, and the other accurate and final for the working drawings. The most important part of the design was the preparation of the calculations and stress diagrams. The calculation work was divided in the following manner : (1) Load sheets for beams and girders ; (2) load sheets for columns and struts ; (3) stress sheets for beams and girders ; (4) stress sheets for columns and struts ; (5) column load sketches, giving accurate conditions of eccentric loading on columns ; (6) detail sketches in connection with which strength of details and connections were calculated.

Printed forms were used as far as possible.

It was necessary to use a complete and carefully thought-out system in order to get through the work with the required accurary in the time available. For the purpose of reducing the work and obviating as far as possible clerical errors, all loads were figured in one and the same unit—viz., thousands of pounds, and not in tons or cwts., and this unit was for shortness called " Kip," an abbreviation of the word " kilopound." The unit of length was 1 in. Bending moments were figured in kips and inches. Stresses were given in kips per sq. in. The author has used this system with good results for the last six years.

Marking.—For accurate calculation, economic designing, and speedy erection an elaborate system of marking the different steel pieces was adopted, every piece having a different mark. The basis for the marking was the numbers of the columns. On the east side of the centre line of the building the columns were numbered from 1 to 70, and on the west 101 to 170, and in such a manner that similarly located columns had like numbers; for instance, column 5 would be similar but opposite hand to column 105. All beams and steel pieces around a certain column were marked with a number, beginning with the column number. For instance, a beam in the panel next to column 164 was numbered 1641, 1642, 1643, etc.

Columns or vertical members were referred to by their number and the storey or tier they belonged to. Beams or horizontal members were identified by number and name of floor. The lowest tier of column 115 is called Framing Tier " A " Column 115, and marked A115; and a beam forming into same at the basement floor is called basement floor beam, 1151, and marked B. Fl. 1151—a similar beam at the second floor is marked 2 Fl. 1151.

Eccentric Loading.—There are in all 132 columns wholly or partially extending from the foundations to the roof, with connections at eight different floors. The columns are figured not only for direct compression load, but also for eccentric loading applied on different brackets on any side of the columns.

Framing Plan.—This constitutes the collected and concentrated result of the particulars given in the calculations, and that ascertained from the sections and constructional details. Section lines with references Nos. or letters are shown on the framing plans indicating that sections or details are made. The framing plans show the size, position, as well as mark and level of the different members of the structure. A diagram plan indicating each member with a single heavy line can be made more accurately and distinctly than a plan showing all details and actual views of the members, particularly if the scale is small.

Foundations.—The foundation work was rendered difficult on account of the depth required (about 37 ft. below street level), the permanent water level being higher than the lowest part of the structure.

The swimming bath and the ejector chamber are constructed as tanks immersed in water. An asphalte damp course ¾ in. thick is laid below and around the foundations, and under the 12-in. thick basement concrete floor. It was found during construction that the permanent water level was about 32 ft. below street level, and that by pumping the water could be temporarily lowered to permit the concrete foundations being laid, sumps being constructed in different positions to collect the water. In some cases piling was resorted to to prevent the water undermining the adjoining foundations. The excavated ground consisted of gravel and sand, and was partly used for making concrete. It contained a small proportion of clay, but not sufficient to materially reduce the strength of the concrete. Tests were made, and the result indicated that the concrete used was about 5 per cent. to 10 per cent. weaker than Thames ballast concrete. The mixture consisted of 1 part of cement, 2 of sand, and 4 of gravel, passing 2-in. mesh.

Each tier of column is, as a rule, supported on isolated foundations placed at different levels to suit drains, ducts, lift pits, baths, and surrounding work, the size in all cases being proportionate to the total dead load and part of the live load, a load of 5,000 lb. per sq. ft. being allowed on the ground. The average load on each column was about 300 tons, and the average size of column foundation 11 ft. by 11 ft. The columns were carried on two-layer steel beam grillages embedded in 1 : 2 : 4 gravel concrete. The centre line of the column above was marked on the top layer grillage, and the grillage set to exact position by means of a theodolite. This method ensured the columns being placed in correct position. The thickness of concrete below the beams was 18 in. above the asphalte course and 6 in. below same.

The external wall of the Carlton Club next to the new building was underpinned the entire length. No cracks or settlement occurred either during underpinning or after the completion of the building, because the size of the foundations was well proportioned to the load.

Walls.—All the walls, with the exception of the east and west external walls, are supported on steel girders and steel columns. The internal partition walls and piers are built in 2½-in. to 4-in. thick pumice concrete blocks or hollow brick tiles. supported at each floor level on steel beams or girders. In some cases the partition walls or piers for the decorative work are supported on the reinforced concrete floor

Columns.—The steel columns are generally built up of angles and plates, the web plate being 12 in. wide and the flange plates 14 in. In some cases the section had to be of a smaller size to suit the diameter of the finished architectural column.

The columns are made in two storey lengths and are spliced about 2 ft. 6 in. above the floor level, the upper tier being connected to the lower one by means of two 14-in. by ½-in. splice plates. A milled butt joint is relied upon for transmitting the load, great care being taken in machining it. The beams are supported on angle brackets riveted to the sides of the columns.

Central Well.—It may be of interest to refer to the setting of the columns for the elliptical vestibule. The columns were set out in full-size on a template floor, and centres arranged to suit a line of a true ellipse. The webs of the columns were set at right angles to the tangent of the ellipse drawn through a point on the ellipse opposite the column centre, the line of the true ellipse being 10 in. inside the column centre line. This arrangement afforded easy connections for beams around the central well, and permitted the introduction of cantilevers. The steel columns form the core to the architectural columns in the vestibule and carry the external wall round the central area. The skylight over the vestibule is carried on cantilevers riveted on the columns.

Girders.—The heavy girders at the second floor were built up of plates and angles, having one, two, or three webs according to load span and depth allowable, which was limited by the requirements of the decorations.

Floors.—The columns were placed generally 12 ft. apart, the main girder between the columns acting as floor beams, the span of the floor construction being about 12 ft.

The floors are constructed in concrete flat slab, about 6 in. thick, reinforced by indented steel bars.

All the steelwork is cased with concrete at least 2 in. thick, properly secured by steel wire reinforcement. The concrete used for the floor construction consisted of 1 part cement, 2 of sand, 2 of broken brick, and 2 of clinker.

Suspended Ceilings.—In cases where the steel girders projected below the soffit of floors, and flush ceilings were desired, a false ceiling made of concrete blocks carried on steel angles and tees was suspended from the floor above.

Staircases.—These are constructed in concrete and carried on steel beams and strings, with the exception of two staircases made in reinforced concrete.

Roofs.—The roofs are constructed in reinforced concrete supported on steel beams and struts. The flat roof is covered with a layer of asphalte ¾ in. thick.

Loads.—The lower floors and public rooms were calculated for a total load of 220 lb. per sq. ft., and the upper or bedroom floors for 160 lb. per sq. ft. The weight of stonework was assumed to be 150 lb., brickwork 120 lb., brick and clinker concrete 120 lb., and stone concrete 150 lb. per cu. ft. Allowances were made for special loads to be carried, such as fans, lift machinery, water tanks, heavy decorative work and concrete filling for making slopes on flat roofs.

Stresses.—The steel was made to a carefully drawn up specification and inspected at the place of manufacture. The ultimate tensile strength of the steel was from 28 to 32 tons per sq. in. of original cross section of piece tested, and minimum elongation of 22 per cent. in 8 in. The percentage of sulphur and phosphor was limited, and bending tests specified. The working stresses were : *Beams* : Tension and compression, 16,000 lb. per sq. in. *Built-up Girders* : Tension and compression, 15,000 lb. *Shear* : 10,000 lb. *Bearing for rivets* : 20,000 lb. *Steel Columns* : Maximum direct stress 12,000 lb. per sq. inch. The sum of direct stress and bending stress due to eccentric loading was not to exceed the safe stress for columns. The formula used for safe stress on columns is similar to that contained in the L.C.C. General Powers Bill.

Retaining Walls.—The front retaining wall is constructed in mass concrete, the unusual form being due to the space required for pipes in the street, and the special provision in the lease as to rights of space for vaults.

The reinforced concrete retaining wall at back is 38 ft. high, the thickness at base 3 ft. 9 in., and at ground floor level 14 in. At a level of 28 ft. below the ground floor the thickness is 2 ft. 9 in. The width of the toe varies from 15 ft. to 22 ft., and the thickness from 3 ft. to 18 in. The toe of the retaining wall in some cases supports columns, and is calculated accordingly.

The concrete was composed of 1 part of cement, 2 parts of sand, and 3 of crushed gravel from site passing $\frac{3}{4}$ mesh. Crushing tests of 6-in. concrete cubes were made, and it was ascertained that the sand and gravel were satisfactory. The work was carried out slowly and very carefully, and struts were not removed until six weeks after the laying of the concrete. After the struts were removed the holes through the wall were filled up with concrete, the back of the wall asphalted, and the filling at back put in position.

The wall is reinforced with $1\frac{1}{4}$-in. indented steel bars spaced 4-in. centres. All reinforcement was placed in exact position and held by means of struts and wires attached to the centering.

Swimming Bath.—This is 86 ft. by 30 ft. by 8 ft. deep, and constructed as a reinforced concrete tank, the bottom being 4 ft. below the permanent water level. It is independent of the main structure, the foundations of the columns being below the bottom of the bath. The sides, bends, and angles are well reinforced with two layers of bars top and bottom laid crosswise, and all reinforcement is wired together and carefully executed.

During construction a sump hole was left through the concrete in the middle of the bath for the purpose of keeping the site clear of water. When the concrete was finished and set a cast iron cover was bolted to a cast iron frame set in concrete round the opening and the sump was sealed and made perfectly water-tight. Concrete was filled on the cover and the marble lining of the bath was completed.

NEW WORKS IN CONCRETE

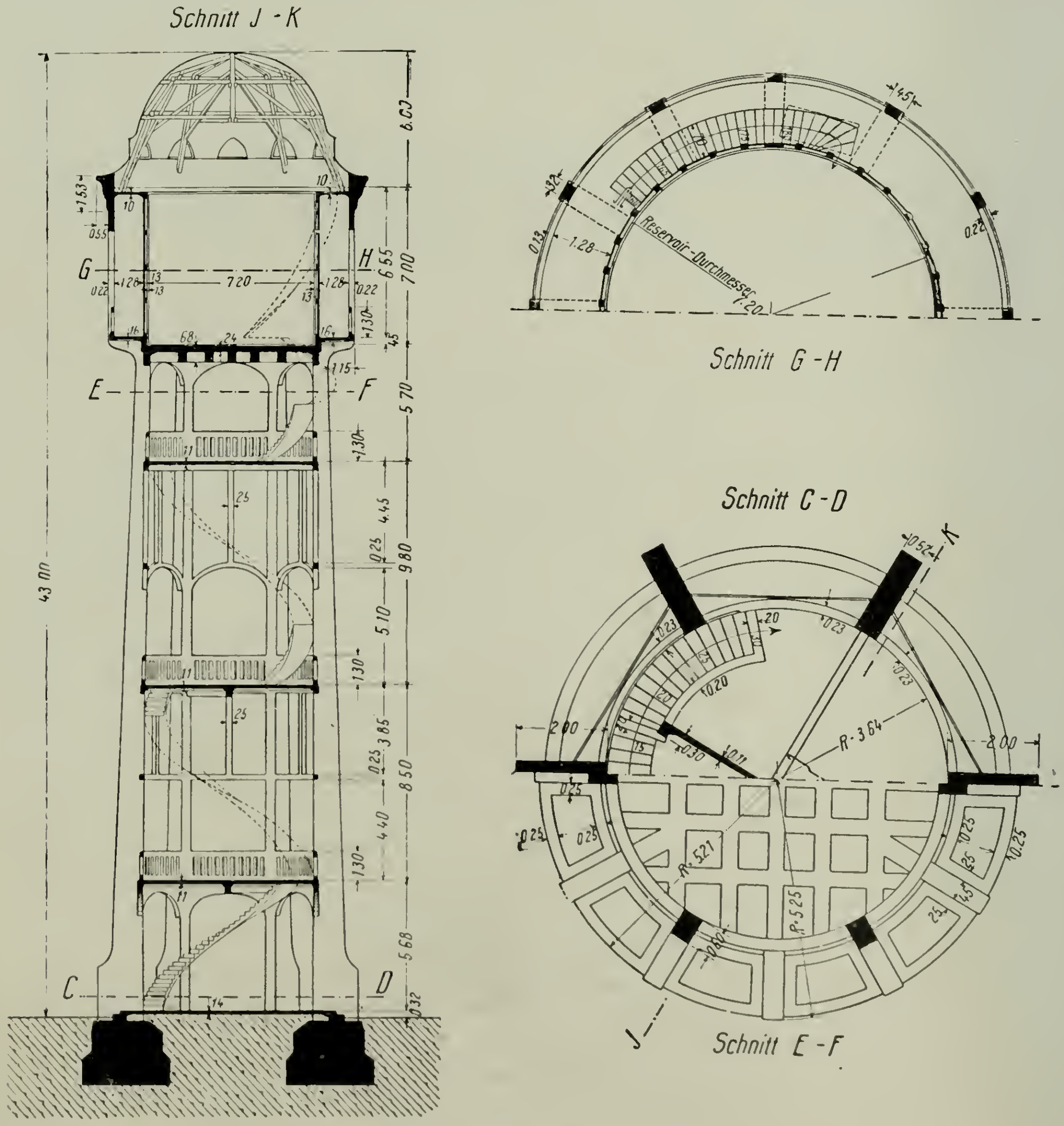
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE WATER TOWER, 141 FT. HIGH, AT SINGEN, GERMANY.

A REINFORCED concrete water tower, 141 ft. in height, has been recently completed at the Maggi Co.'s Sauce Factory, at Singen. The contract was given, as the result of a competition, to Messrs. Josef Krapp, of Karlsruhe, to whom the design and execution are due. The structure is described by F. Guske, engineer to the latter firm, in *Beton und Eisen* (which paper supplied us with the illustrations), the architect being H. Steub.

The base of the reservoir is 98 ft. 5 in. above ground, and the six columns taper from 6 ft. 6 in. by 1 ft. 8 in. at the base to 2 ft. by 1 ft. 6 in. at the top. The foundation is ring-shaped, with an outer diameter of 41 ft. and an inner diameter of 16 ft. 6 in.

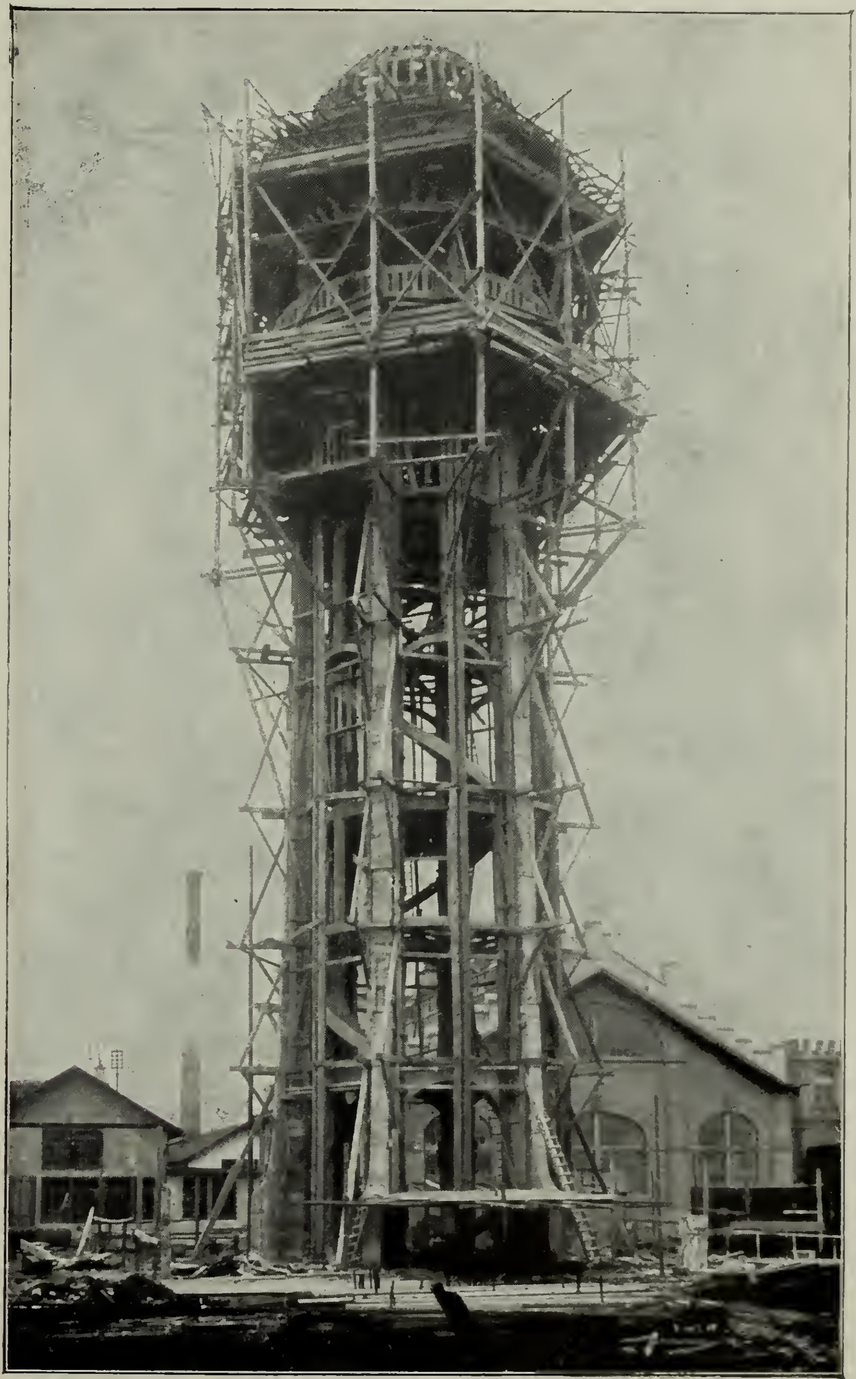


Details of construction.

REINFORCED CONCRETE WATER TOWER AT SINGEN, GERMANY.

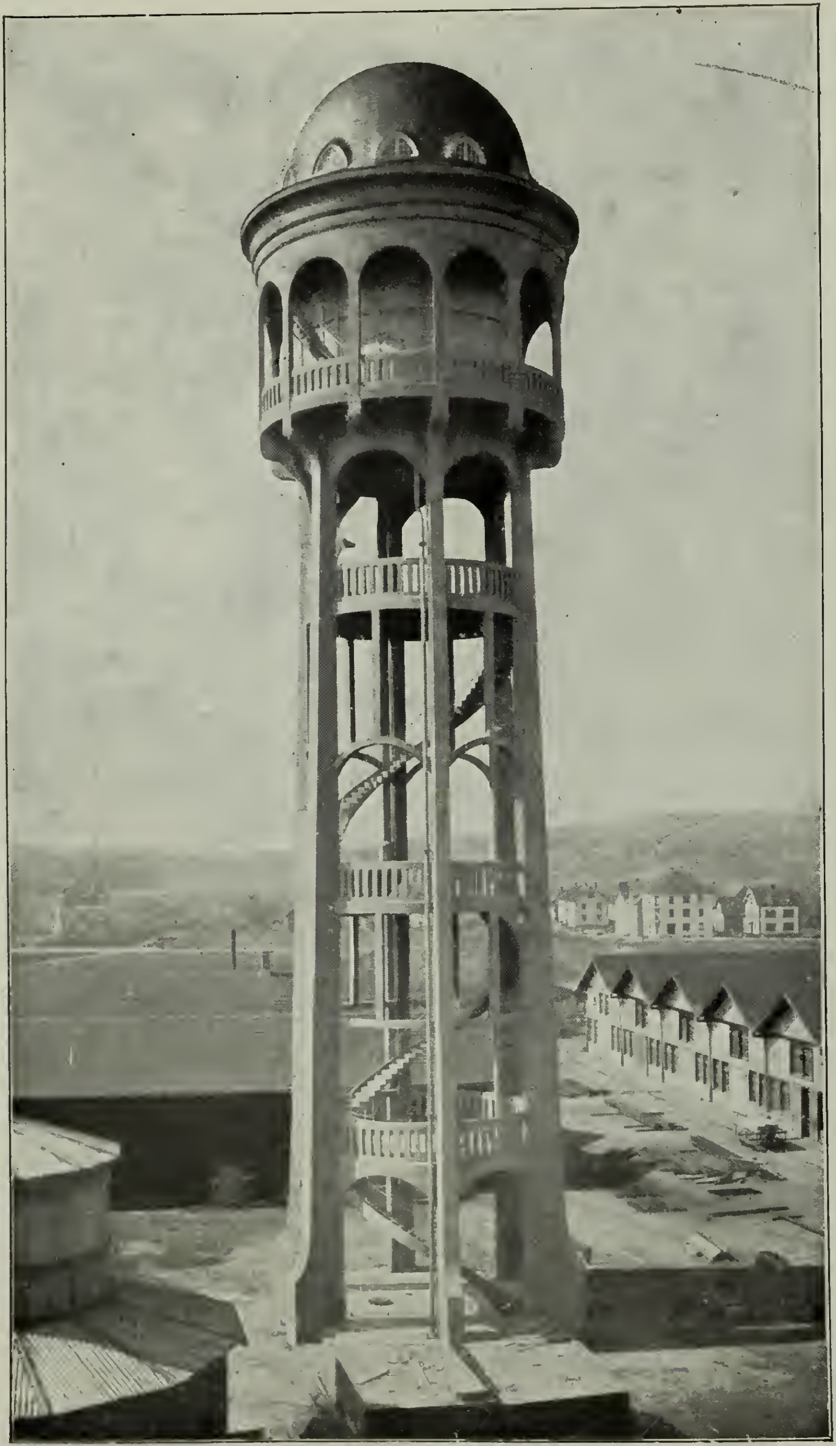
The general appearance of the tower during construction is shown on this page, and when completed on page 222. The details of construction are seen on pages 220 and 223.

The floor of the reservoir is constructed in panel form, the depth of the ribs being 2 ft. 3 in., and the thickness of the panels 9½ in. Below this level are three other floors, which serve to brace and stiffen the structure. The spiral staircase is carried on concealed corbels. The gallery surrounding the reservoir is also carried on reinforced concrete corbels. The reservoir itself is not of reinforced concrete, but of steel plates, this having been preferred by the owners on the ground of greater facility for repair. Its internal diameter is 23 ft. 9 in., and its height 21 ft. 8 in.



Work in course of construction.
Reinforced Concrete Water Tower at Singen, Germany.

It is provided with a non-conducting casing, consisting of movable slabs of pumice concrete, inserted between very thin vertical concrete supports, the space between the steel and the slabs being filled with dry peat. The roof, which was originally intended to be of reinforced concrete, had, on account of unfavourable weather conditions, to be constructed of wood, covered with slates, and in the upper part with copper. The stair treads are of iron.



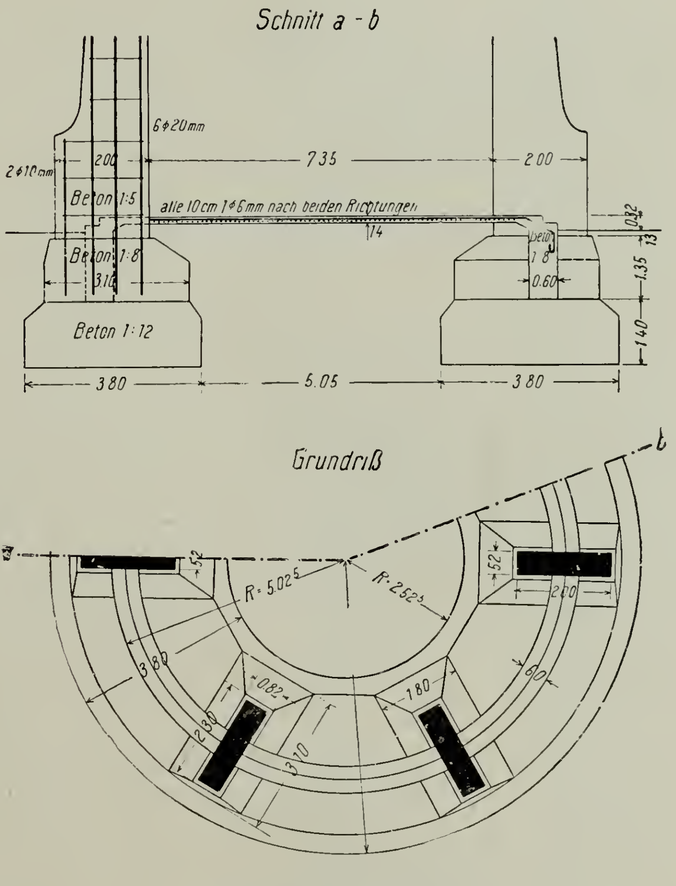
View of finished structure.

REINFORCED CONCRETE WATER TOWER AT SINGEN, GERMANY.

The concrete used was prepared with Immending basalt, a 1 : 12 mixture being used for the lower part of the annular foundation, and a 1 : 8 mixture for its upper layers ; whilst the portions above ground are of 1 : 5 concrete, with the exception of the floor on which the reservoir rests, which is of 1 : 3½ concrete. All exposed faces are dressed with a tool to give a rough surface.

A wind-pressure of 30 lb. per sq. ft. was allowed for. The load on the soil (a good gravel) is 23 lb. per sq. in., and the greatest compressive stress in the structure is 467 lb. per sq. in.

Building was begun on June 1st, 1909, and on October 5th the reservoir was filled in order to test the floor on which it was supported. When water had been filled in to a depth of 20 ft. 4 in., the centre of this floor showed a depression of 3·15 millimetres (0·124 in.). The tower was set in regular use in December, and has stood well since, although violent storms occurred both during, and shortly after, its erection.



Details of construction.

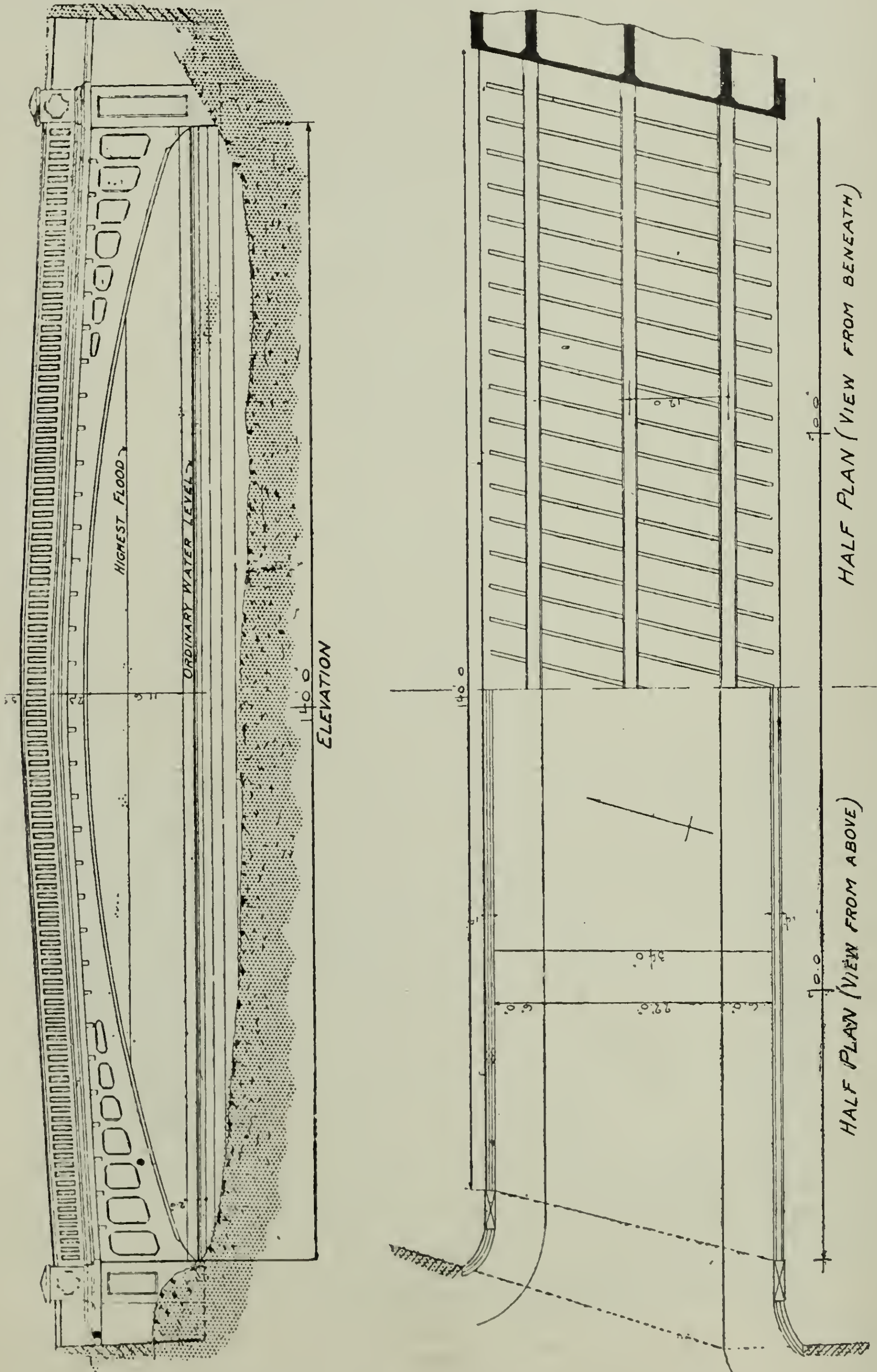
Reinforced Concrete Water Tower at Singen, Germany.

REINFORCED CONCRETE BRIDGE OVER THE NORE, KILKENNY.

The new bridge over the river Nore, at Kilkenny, is constructed of reinforced concrete on the Hennebique system. The bridge was designed for the Joint Committee of the Kilkenny County Council and the Kilkenny Borough Council by Mr. A. M. Burden, M.Inst.C.E., County Surveyor of Kilkenny.

The bridge has a total length of 196 ft. and a total width of 36 ft. 4 in. The arch of the bridge crosses the river in a single span, and consists of three parallel ribs 2 ft. wide, spaced 12 ft. apart, centre to centre, each rib being 2 ft. 6 in. thick at the springings and 2 ft. at the crown. Fourteen vertical spandril columns, 12 in. by 12 in., rise from the ends of each rib and support the main longitudinal beams, 14 in. wide by 24 in. deep, of the road platform above. The total thickness of the arch at the crown is 2 ft. 6 in.

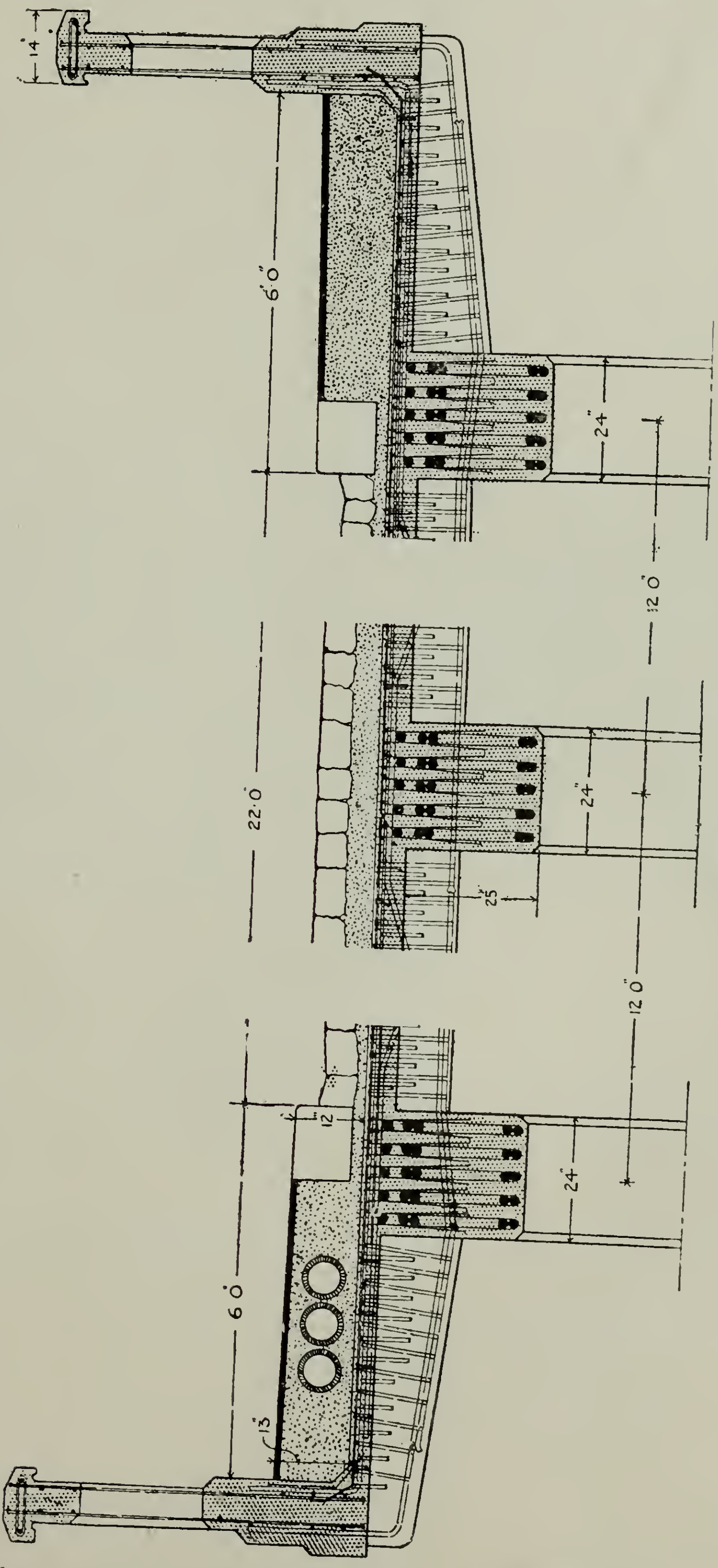
Support for two footpaths and parapets is provided by extending the transverse beams of the road platform so that they project 3 ft. beyond the outside face of the main longitudinal beams. The platform slab also continues over, and piling, on which the parapets are built, connects these projecting beams.



Elevation and plan.
Reinforced Concrete Bridge over the Nore, Kilkenny.

The horizontal beams of the abutments are supported by reinforced concrete piles driven deep into the earth, and the pile heads are incorporated with the beams, so the abutments with their foundations and connected piles are monolithic throughout. The abutments are also monolithic with the arch, which makes the whole structure absolutely solid.

The roadway of the bridge is paved with granite setts on a concrete foundation. The official tests which were carried out on the bridge gave very satisfactory results. A dead load of 220 tons was distributed some days before the test over the main beams and footpaths, leaving a passage over which two trains were driven, the total weight of each train being 45 tons. The minimum deflection under the moving load was less than $\frac{1}{4}$ in. at the centre of the arch ribs. When the live load was removed



Cross section at crown of arch.

Reinforced Concrete Bridge over the Nore, Kilkenny.

two-thirds of this deflection disappeared, and the remaining one-sixteenth of an inch was made good on the removal of the dead load.

The details of the reinforced concrete construction were prepared by Messrs. Mouchel & Partners, of Westminster, the contractors being Messrs. J. & R. Thompson, Ltd., of Belfast and Dublin.

We are indebted to *Ferro-Concrete* for the line blocks illustrating this article.

Reinforced Concrete Bridge over the Nore, Kilkenny.

BOUNDARY WALL, 7,500 FT. LONG, BUILT OF CONCRETE BLOCKS.

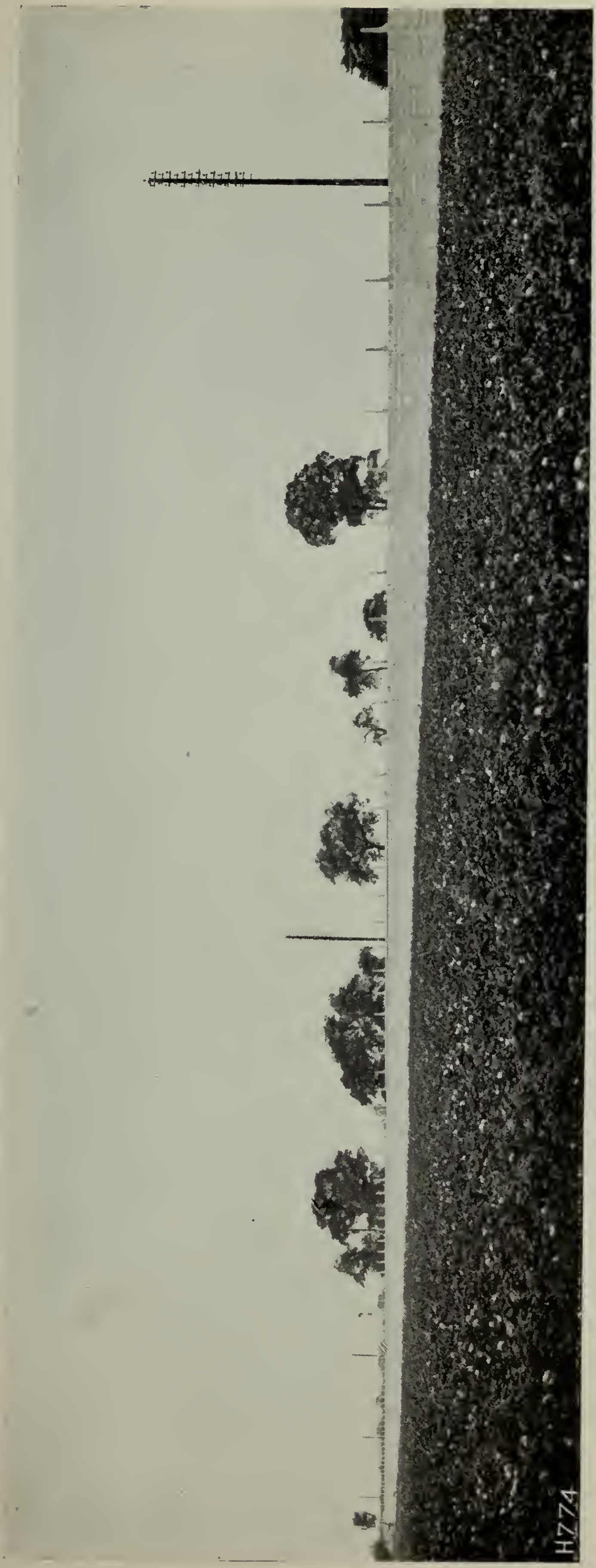
Hitherto boundary walls have generally been constructed with stone or bricks, and have always proved expensive to erect and maintain, the most flimsy wall being 9 in. thick if in brickwork, and of no great height, and they are of much greater thickness, with buttresses, if of any height exceeding, say, 7 ft. Stone walls are of still greater thickness.

It has remained for one of our Government Departments—*i.e.*, the Prison Commission—to introduce a method of erecting boundary walls which meets all requirements in a manner at once economical and structurally sound.

The wall described has been erected at the Borstal Institution, Feltham, under the superintendence and to the design of the Surveyor of Prisons (Major H. S. Rogers, R.E.).

The wall is 7,500 ft. long. It is 4½ in. thick, with piers at intervals. The height is 7 ft. 7½ in. to top of coping, and 9 ft. 9 in. to top of barbed wire. Work was commenced on April 28th, 1910, and was completed on October 5th, 1910, the total cost being £2,591.

A view of the completed wall is shown on page 227. It is built with reinforced concrete piers at intervals of 13 ft. 8½ in., the piers being 12 in. by 9 in. in plan by 12 ft. 10½ in. long over all, and twice rebated to receive the 4½-in. hollow concrete blocks. The piers are set 2 ft. 6 in. in the ground on a bed of concrete 1 ft. 9 in. by 1 ft. 9 in. by 1 ft. The upper portion is diminished so as to become an upright post to carry 5 lines of barbed wire. In the sides of the rebates are embedded steel wire



View of a portion of the completed wall.

Boundary Wall at Borstal Institution, Feltham.

mesh spaced so as to fit into the bed joints of the $4\frac{1}{2}$-in. hollow concrete blocks. The bed joints are also reinforced with steel wire netting.

The lower illustration on page 228 shows the method of constructing the piers in one piece in wooden moulds.

On page 228 an illustration is also given of the "Winget" concrete block-making machine, in which the $4\frac{1}{2}$-in. hollow concrete blocks for the wall were made.

The blocks are $28\frac{1}{2}$ in. long, 9 in. high, and $4\frac{1}{2}$ in. thick, with recessed end joints. Each block has two hollows and they are made two at a time in the machine.

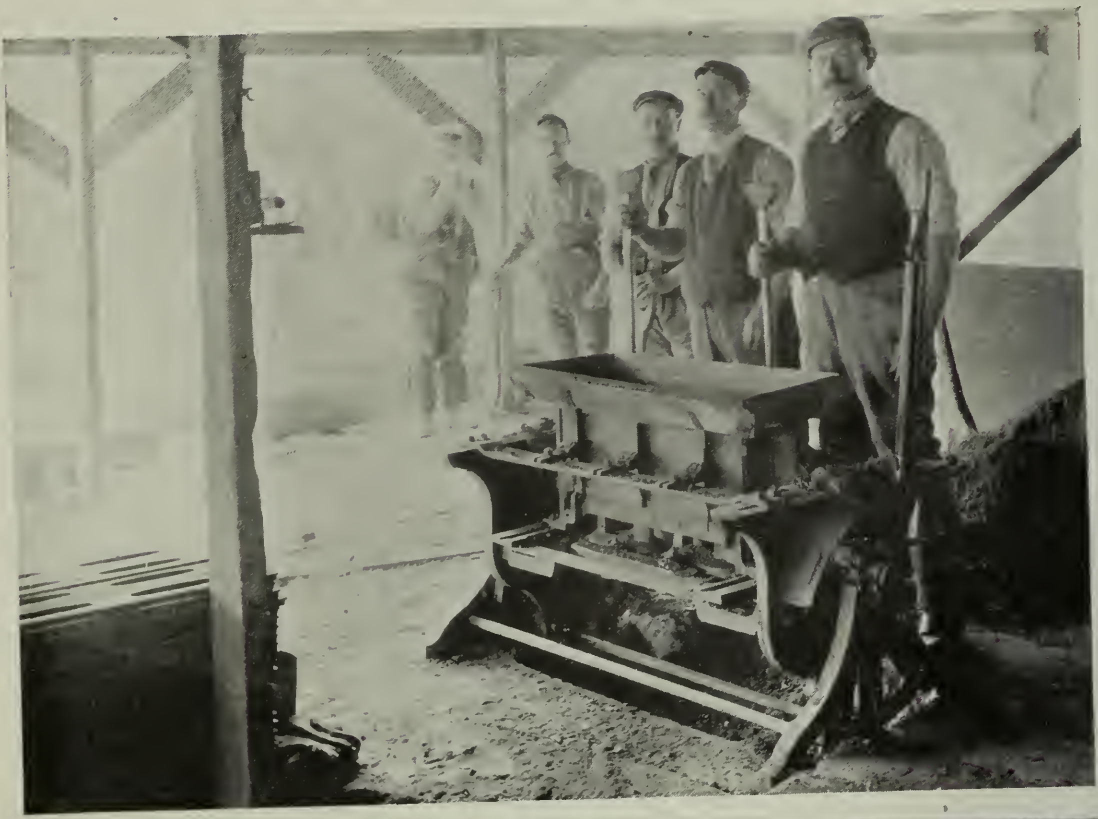
Six men made and stacked 400 of these blocks per working day of 10 hours, and one bricklayer and two labourers erected in one day 16 ft. by 8 ft. of wall, one pier and 2 ft. foundation blocks.

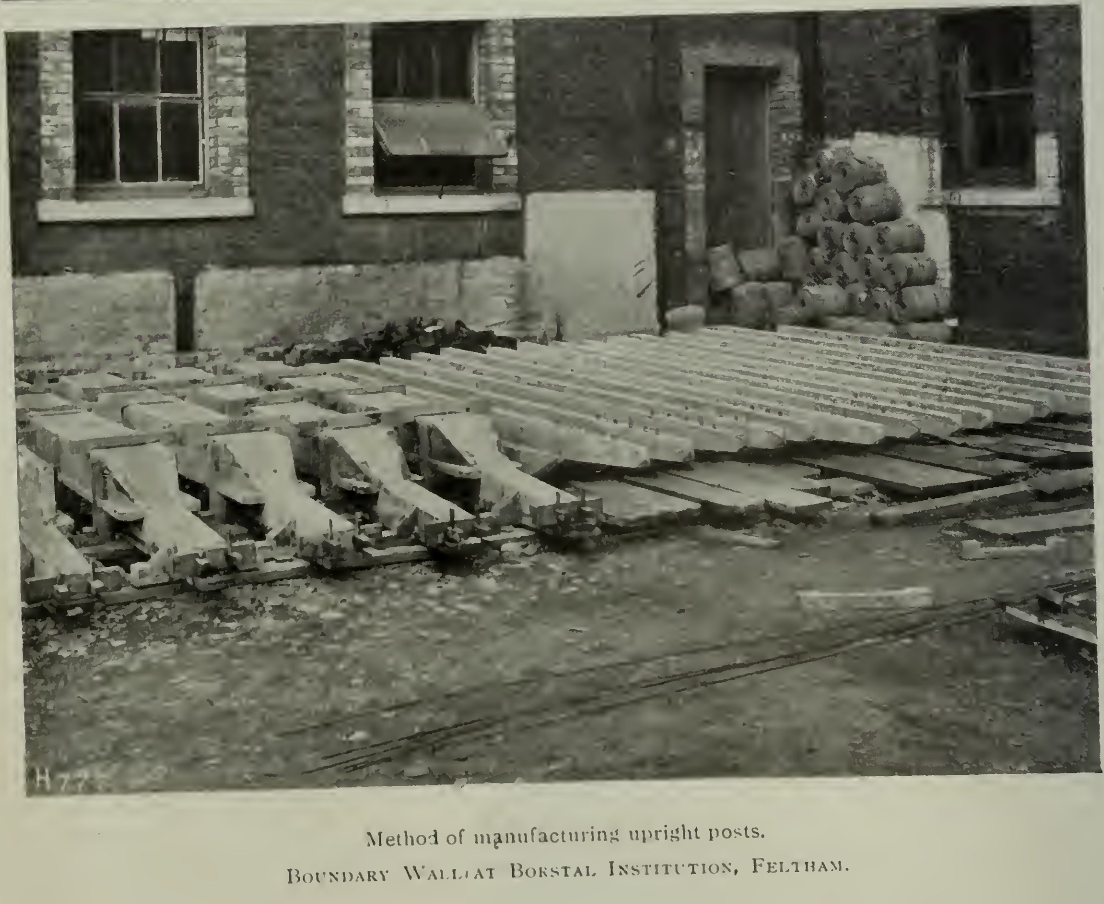
The proportions used in making these blocks were 4 parts of clean $\frac{1}{2}$-in. gravel to 1 of Portland cement.

The mode of construction is so novel, and also so thoroughly strong and satisfactory, that it must mark an epoch in this class of work.

No doubt the use of reinforced concrete for the piers along with thin, hollow concrete blocks for the panels has made possible a form of construction which may be followed with advantage by many of our readers. Where gravel and sand suitable for aggregates are obtainable, there is no reason why this method of construction should not be followed, as the

"Winget" Machine making blocks.

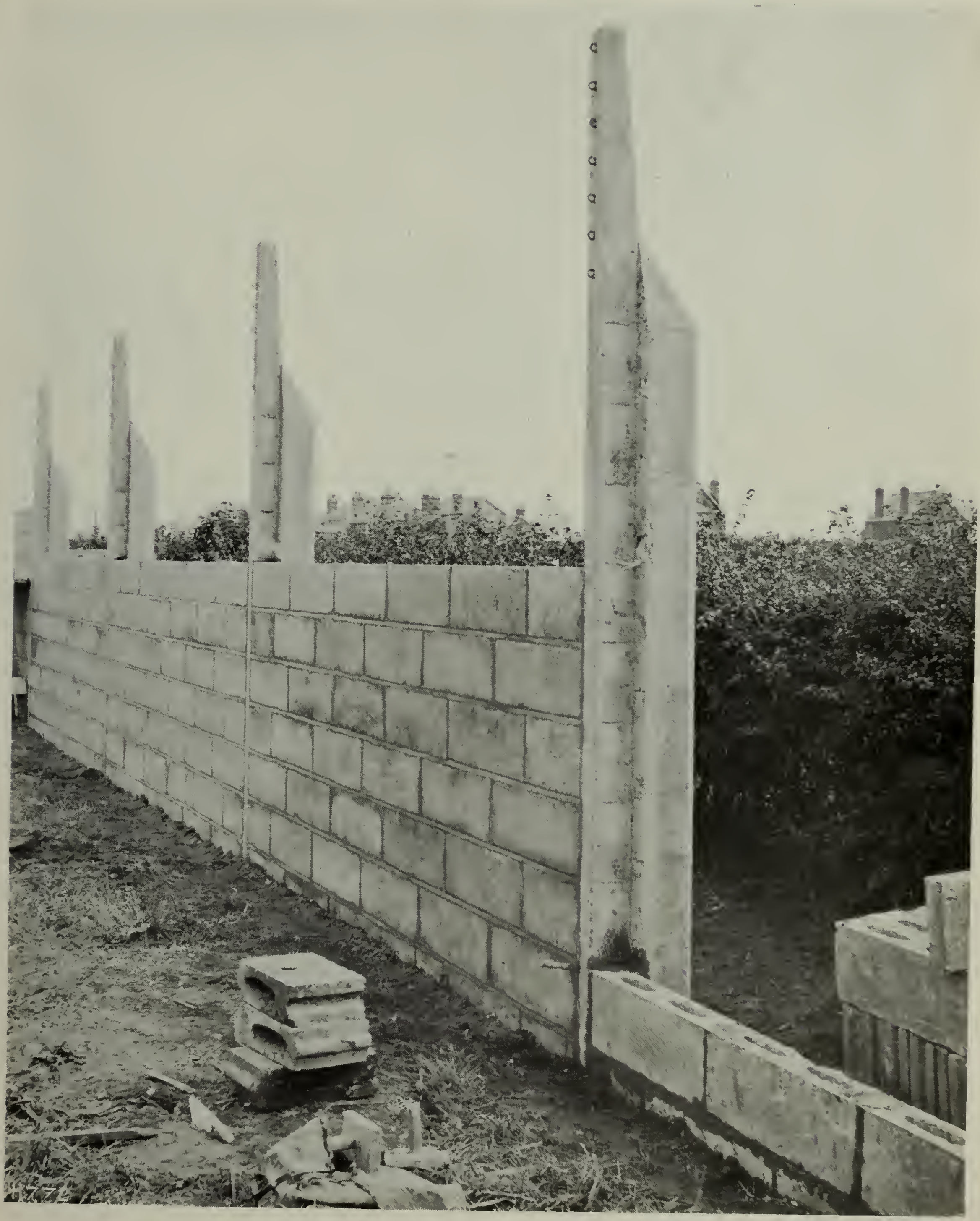




Method of manufacturing upright posts.

Boundary Wall at Borstal Institution, Feltham.

blocks may be made without skilled labour or power, and they can be made on the job, thus saving carting and handling.



View of wall in course of construction, showing upright posts.
Boundary Wall at Borstal Institution, Feltham.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

NOVEL CONSTRUCTION OF CONCRETE HOUSE IN GLENCOE, ILL., U.S.A.

THE residence of Mr. Frank Darling, at Glencoe, Ill., designed by himself and described in this article, affords a practical example of the convenience and economy of concrete as a material for medium-cost concrete houses.

The construction of the house is unique. The foundation is built of four-way conduit tile, laid in a trench 15 in. wide and built up 18 in. above the ground. For outside walls concrete was poured 6 in. thick on outside of tile, and above the ground forms were erected to pour 4 in. walls. The four-way tile was stopped about 6 in. above ground and single conduit laid from that point up. Partition walls throughout were of single conduit plastered on inside without lath. No cracks have appeared.

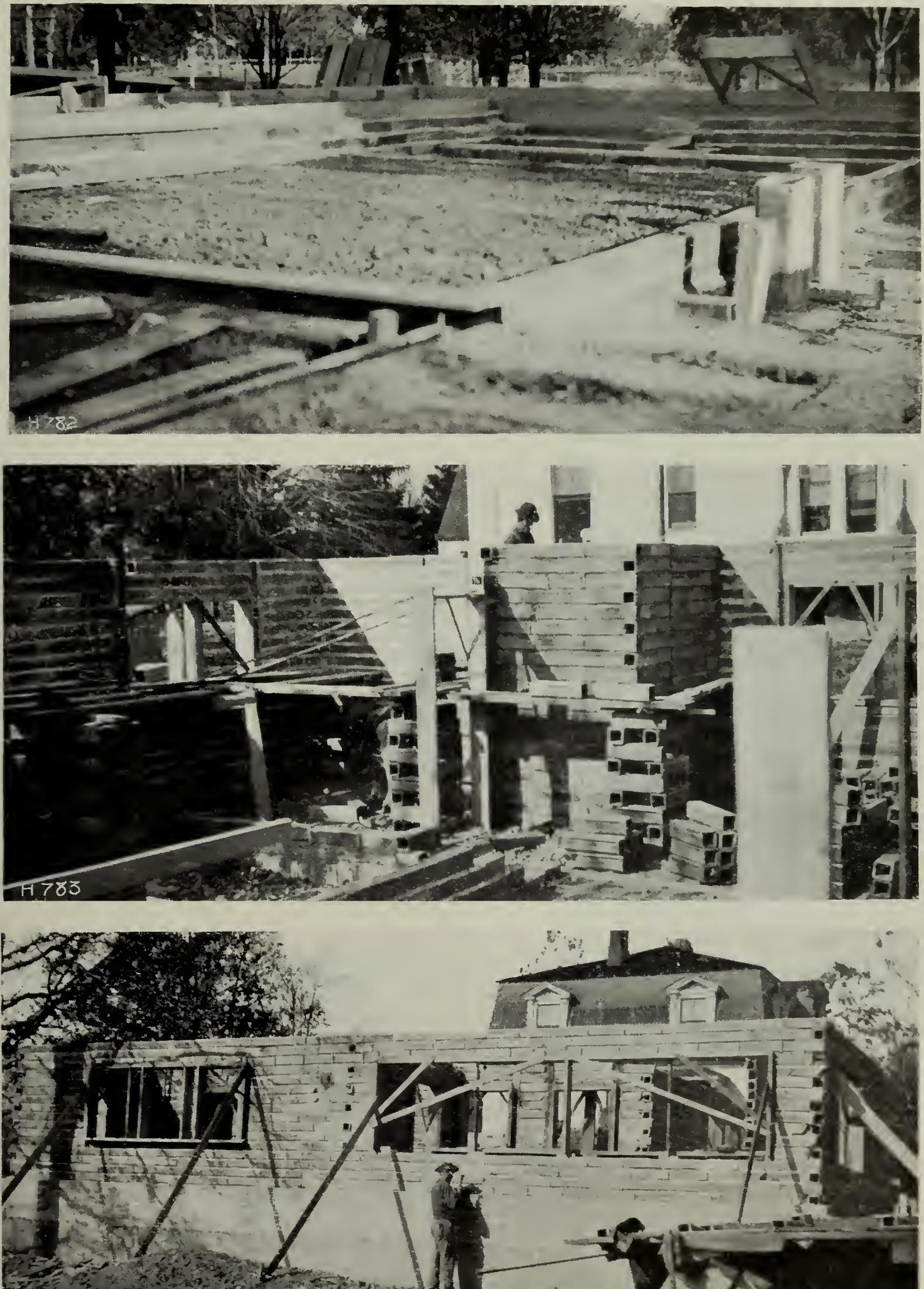
Heavy cypress window and door frames were used throughout with rabbeted plank frames. When the conduit was built to the height desired, the frames were set and braced in, allowing $\frac{3}{4}$ in. inside of tile surface for plaster. Conduits were then laid up snug to frames, being placed on end to form mullions between windows.

All outside frames were designed to come flush with the finished surface of the poured concrete, the concrete being 4 in. thick. Each outside frame had a $1\frac{1}{2}$-in. by $1\frac{1}{2}$-in. strip nailed around it, setting flush with the outer edge, the concrete set back of this cleat making a wind- and air-tight joint. Forms were built to half window height and then poured. The forms were fastened to the frames and wired through the conduit. When the forms were in place long 2-in. by 4-in. bracing strips were run lengthwise and tied through the tile wall with galvanised wire twisted up tight to prevent bulging.

The concrete was mixed and poured very wet, allowing it to flow into spaces left between conduits and into all channels provided around window and door frames. This gave a splendid bond and produced a solid wall.

CONCRETE HOUSE AT GLENCOE, ILL., U.S.A.

For aggregate, gravel of about 1 in. to 1½ in. was used showing as many different colours as possible. When the forms were removed the lines showed plainly, but the whole surface was bush hammered, ¼ in. being taken off in this manner. The resulting surface is uniform, but the coloured pebbles relieve monotony.



Views of house in course of construction.
Concrete House in Glencoe, Ill., U.S.A.

The floors on the first floor are of solid concrete with 2-in. by 2-in. nailing strips set in 1 in. above concrete. The form boards were used for the rough flooring (placed diagonally), and the $\frac{7}{8}$-in. oak floor placed on top.

The first and second floor porches are floored with concrete. The second-floor porch has a suspended concrete floor 5 in. thick, and is 50 ft. by 12 ft. in extent.

All interior plaster is cement mortar mixed with torpedo sand only, and troweled rough. Oil stain was used on the plaster, and as it allows the grain of the plaster to show through, the effect is very pleasing.

The chimneys are all built of poured concrete, flues being lined with clay flue lining. The fireplace is concrete with a brick facing, and has a drum arranged to throw the chimney heat back into the room.

The electric wiring runs through the conduits in the walls. This feature was well planned in advance, that vertical conduits might be placed to provide for wires up and down. Each floor was wired separately before the concrete was poured.

The wall structure, completed with its component parts, has four inches of monolithic concrete on the outside, closely bonded to the vitrified conduit tile. The tile wall is $\frac{7}{8}$ in. thick, leaving a $3\frac{1}{2}$-in. air space between the two tile surfaces. The cement plaster, $\frac{3}{4}$ in. thick, lies on the inner surface of the tile, making, in all, a solid wall of 10 in. in thickness.

The construction insures a practically fireproof and thoroughly vermin-proof house. The same valuable consideration which is characteristic of all concrete residences is very noticeable in this house : the absence of vibration throughout the structure, though this house is placed within 200 ft. of the railway tracks.

While the owner has applied for a patent covering the wall construction of tile and concrete, it is not his intention to make a profit out of the invention, but to hold it so that anyone may have the right to use the construction by simply obtaining permission.

The particulars in this article are taken from the *Cement Age.*

Reinforced Concrete Water Barrel.

REINFORCED CONCRETE WATER BARREL.

A novel application of reinforced concrete is in the construction of water barrels, the one illustrated on this page being made throughout by an amateur.

The walls of the barrel are $1\frac{1}{2}$ in. thick, The total cost was 27s., including the wooden stand at bottom.

The reinforcement consisted of five ordinary boys' hoops, 3 ft. in diameter, and 1 ft. of galvanised wire netting double.

The capacity of the barrel is about 200 gallons, and it has proved most satisfactory.

ENQUIRY COLUMN.

The name and address of enquirers must always be given, not necessarily for publication. The advice given in reply to enquiries is a matter of personal opinion, and although contributed in most cases by experts with special knowledge of the matter in question, it must not be considered in the same light as if obtained from a Consulting Engineer, Architect, or Solicitor, who should always be referred to in important cases, as our columns are not intended to do away with the services of the professional experts on constructional or legal matters.

Replies will be sent by post if the enquiries are marked "Answers by Post" on the outside. All other enquiries will be replied to in this column.—ED.

REINFORCED CONCRETE WATER CONDUIT.

F. R. (Alexandria) writes: It is proposed to construct a reinforced concrete water conduit of 42-in. diameter, cast *in situ*, and laid 2 ft. underground. The length of the conduit is about 3,000 ft. Manholes will be placed in the conduit at intervals of 600 ft. No provision has been made for expansion joints. Are these absolutely necessary? The variation of temperature to which the conduit will be exposed is trifling. The reinforcement consists of iron rings ⅜ in., spaced 10-in. centres, and held horizontally by round bars ⅜ in. The thickness of the shell (concrete) is 8 in. Concrete mixture, 1 : 2 : 4. The assumed water pressure should not exceed two atmospheres.

Reply.—Assuming that there is an excess natural water pressure of 15 lb. per sq. in., we find that the provision of iron rings is insufficient. If ⅜-in. diameter rods are to be used the rings should be spaced about 3 in. apart. The thickness need not be more than 6 in., but it would be advisable to use a stronger mixture of concrete than that proposed. We would advise 1 cement to 1½ sand to 3 aggregate. The expansion joints need not be provided as the variation in temperature would be trivial.

LIMESTONE AS AN AGGREGATE FOR REINFORCED CONCRETE.

E. R. L. (Queenstown).—Will you kindly let us know what is the objection to the use of limestone for reinforced concrete?

Reply.—Limestone can be used quite well as an aggregate for reinforced concrete, some of the finest aggregate, as regards strength, being obtained by the use of Portland stone, which is, of course, a limestone. As it is obvious, however, that limestone, which parts with carbonic acid at a moderate heat, is liable to disintegrate under the action of fire, where fire resistance is important it would be well to avoid it if another material can be obtained cheaply, or else an increased covering must be provided for any embedded steelwork. Limestone will, however, be more resisting if broken to a small size; as reinforced concrete aggregate usually varies from a maximum of ¾-in. down to ¼-in., it has greater resistance to fire than mass concrete where larger stones are required. The strength of the concrete also depends to some extent on the nature of the limestone. Some limestones are of poor quality, not having much weather resistance, so it is only natural that such material when made into concrete will also show a low crushing resistance.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Building Trades' Exhibition, Olympia.—The ninth biennial Building Trades' Exhibition will be opened on Saturday, April 22nd next, by Mr. Leonard Stokes, President of the Royal Institute of British Architects.

No more successful event is associated with Olympia than the Building Trades' Exhibition organised every two years by Messrs. H. Greville and Hugh C. Montgomery; indeed, we doubt whether there is another exhibition of any kind which can in the same way fill the huge building at Addison Road—main hall, annexe, and galleries—from end to end with exhibits connected with the industry immediately concerned.

As before, the galleries will be found to constitute a municipal section for the special benefit of borough surveyors and engineers, whilst the whole of the ground floor is devoted to the multifarious requirements of the architect and builder. The wall which used to separate the main hall from the annexe has recently been removed, the result being that the stands will run continuously from the entrance in Addison Road to the exit in Blythe Road.

Arrangements are being completed for official visits of members of the many associations and societies connected with the building industry, and there is no doubt that the exhibition of 1911 will be an even greater success than any of its predecessors.

Institution of Civil Engineers.—At the students' meeting held on January 20th, Mr. T. Sims, C.B., M.Inst.C.E., in the chair, Mr. G. F. Walton read a paper on "The Design and Construction of Reinforced Concrete Arches." The author described, with the aid of diagrams, the elastic theory for the computations of stresses in arches, and a comparative table showed that the strongest form of arch was continuous from abutments to crown, and, further, that the strength of the arch decreased with the introduction of hinges at the crown or springings, each additional hinge decreasing the carrying capacity of the bridge. The paper concluded with a description of some recently constructed arches of large span.

Early Examples of Reinforced Concrete.—In a recent number of *Surveying and the Civil Engineer* the following notes appear: "Some years ago, in carrying out alterations at the Queen's Head Inn, it was necessary to remove an old concrete beer-cooler. A labourer was set to knock it to pieces, but he had to give it up as a bad job, because he found embedded in the concrete a lattice consisting of 1¼-in. by ¼-in. iron bars. Although every effort was made to ascertain the age of the cooler it could not be fixed with certainty, but it must be at least from fifty to sixty years old. It remains to this day an interesting example of early reinforced concrete, and the concrete is sound and the bars free from rust.

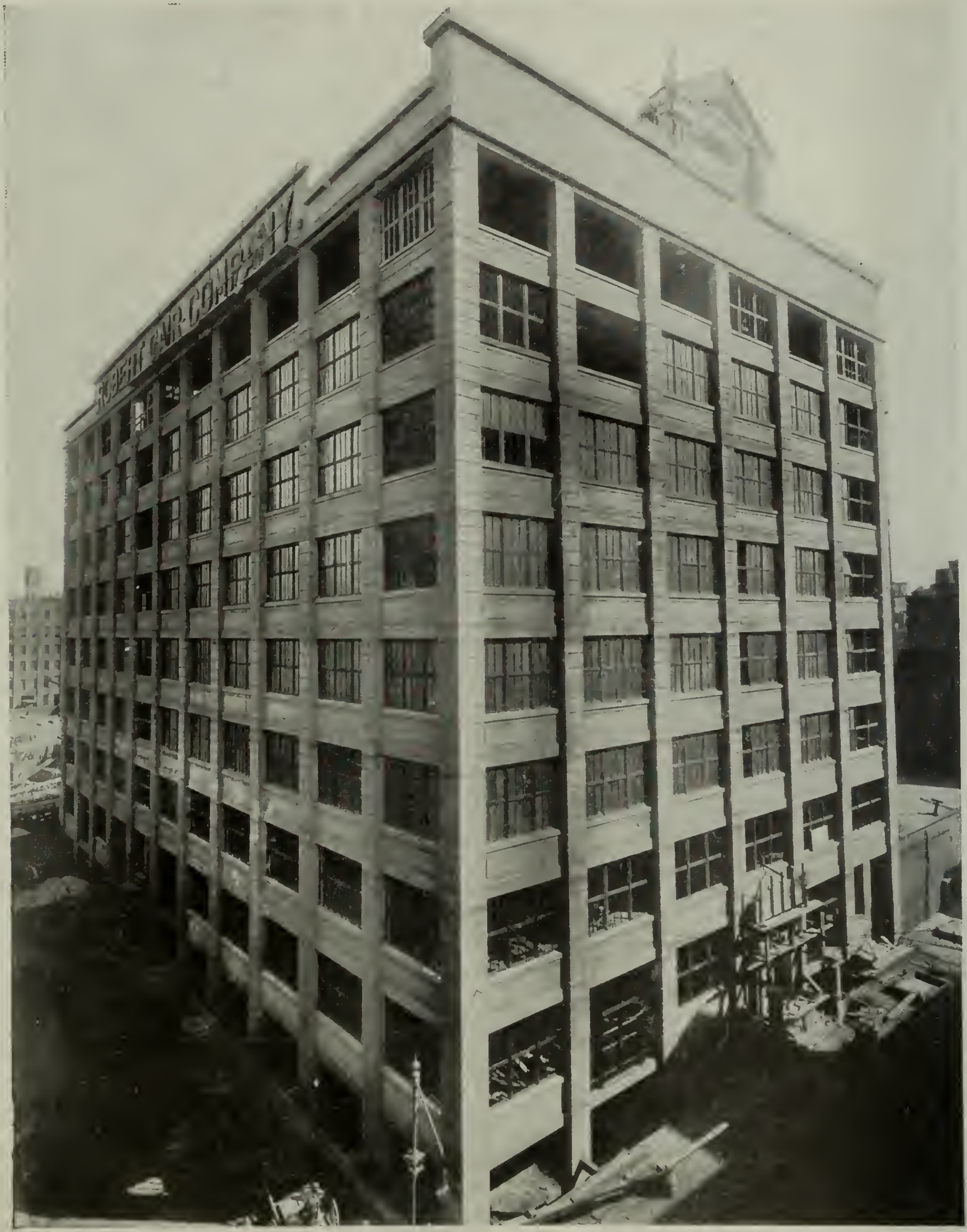
"In 1876 we decided to have a reinforced concrete roof instead of a lead flat. We sent for an expert—I should perhaps say *the* expert. He came, and he used iron bars at about 2-ft. centres, about 3-in. by ¼-in. section. Through these were bored holes, in which ½-in. rods were placed at about 18-in. centres. The whole were embedded in coke breeze concrete, the finished slab being about 4 in. This roof is quite sound to-day, and the reinforcement is sound also, for we left some of the bars standing out about 4 in. in order to fix a fence to it. As far as durability is concerned, the two examples given prove that it would have been quite safe for the Local Government Board to have sanctioned a loan of 30 years on the work. Besides durability, the economic conditions, which have sent the price of timber up from 1s. 2d. to 1s. 9d. per cube ft., and the price of cement down from £3 10s. to £1 10s. per ton, is all in favour of reinforced concrete."

Belgian "Natural" Cement.—In the course of his presidential address to the Devon and Exeter Architectural Society, Mr. Wm. H. May, M.S.A., said that during the past year when in Belgium he visited one of its great centres of the manufacture of cement, and his interest being aroused at seeing large quantities being prepared for the English market, he made, with assistance, observations which reasonably showed that English Portland cement is not only a much superior article, but, if properly handled, more economical than the Belgian. The causes of the inferiority of Belgian cement were due to the uncertainty of the quality of the stone quarried and the method of burning. Some pieces of the rock quarried were identical in composition with Portland cement, whilst other pieces had only the composition of hydraulic lime.

Concrete Floors and Footwalks.—It is an accepted fact nowadays, says the *County and Municipal Record,* that, in laying down new concrete or granolithic, one secret of success is to see that the surface coat bonds with the under concrete. This can be easily obtained by insisting on the work being done in panels or sections, which will be finished complete before new ones are started. In cases where it is required to lay a new surface coat on what is otherwise good, sound concrete, as, for example, in a reinforced concrete floor, it is sometimes not possible, except at great expense and inconvenience, to break up the old material and lay the whole area *de novo* in the way suggested. In these circumstances, if carefully done, the method much used in America should be found satisfactory. This specification is as follows : The top finish shall consist of 1 part Portland cement, 1 part stone from ½ in. to smallest size (excluding dust), 1 part sharp sand, mixed to a stiff paste just wet enough so that in trowelling the water will barely work to the surface. The old under concrete shall be roughened either by sand blast, muriatic acid applied to the surface, or other satisfactory method of cleaning the stones so that the mortar shall easily adhere to them. The under concrete shall be made thoroughly wet, and shall be kept wet long enough to absorb all the water it will take up readily, thus ensuring a base so wet that it will not draw water from the finishing when the latter is applied. At the same time, an excess of moisture must also be avoided, as this would be as dangerous as too little water. The surface of the base shall then be scrubbed with a thin grout of pure cement rubbed on with a broom. On top of this, and before the previous coat has had time to set, a thin coat of finishing, as already specified, shall be trowelled hard, the workman using as much pressure as possible, and rubbing the finishing hard down into the scrubbed base, so that it shall take firm bond. After this the finishing shall be applied to the desired thickness, screeded, and floated to an even surface. Between the interval of initial and final setting it shall be finished by skilled workmen with steel trowels, and worked to a final smooth surface. Under no conditions shall a drier be used, nor shall water be added to make the material work easily. If the work be done in hot weather the finishing shall be protected from the sun and wind in order to prevent too rapid setting.

Sea Defence Works at Holme Cultras, U.D.C. (Cumberland).—The Council's consulting engineers, Messrs. Henry Adams & Son, of Queen Victoria Street, E.C., have reported that the sea wall and concrete apron at Silloth, about 1,400 yds. long, carried out under the first contract, have now been satisfactorily completed, and application has been made to the Local Government Board to sanction a loan in connection with the proposed extension for about 1,000 yds., which is to be carried out as soon as possible.

The Tooling of Concrete Surfaces.—The tooling of concrete surfaces was discussed by a number of members at the convention of the National Association of Cement Users, and their experience indicated that a hammer with 2 to 16 star points gives generally more satisfactory results than a bush hammer. These hammers are made with different numbers of points. This tool, pneumatically operated, is rapid, and common labour when once instructed will cover a larger area with it and do the work as well as skilled labour. While the bush hammer gives a fine finish, it clogs readily, and has a small output. The star-pointed hammer is easily sharpened by merely drawing the temper and using a file on the face to give the desired finish.—*The Engineer.*



Reinforced Concrete Factory in Brooklyn.

Reinforced Concrete Factory in Brooklyn, U.S.A.—The utility of reinforced concrete for factory and warehouse work is undisputed, especially if the plan be a simple, straightforward one. We have presented notable examples of this kind of work on numerous occasions, and are here illustrating the Robert Gair Factory in

Brooklyn, N.J., which is a striking instance of an important structure of this type built of reinforced concrete. The block was placed at our disposal by the *Cement Age.*

The Age of Reinforced Concrete.—Thomas A. Edison, the inventor, in the *Cosmopolitan Magazine* says: "Men are lunatics to keep on building with brick and steel. Reinforced concrete is better and cheaper than either. Builders who stick to brick and steel are behind the times. Men who put up wooden structures are worse lunatics. It is because we use such building materials that the fire losses in this country amount to almost $500,000,000 a year. Think what a waste of materials and labour this sum represents. It is all unnecessary. Reinforced concrete is not only cheaper than brick and steel, but it is fireproof. A reinforced concrete building will stand practically for ever. Within 30 years all construction will be of reinforced concrete, from the finest mansions to the tallest sky-scrapers."

An Instance of the Value of Concrete in Reducing the Cost of Insurance.—At the recent meeting of the National Association of Cement Users of America, Mr. Emile G. Perrot gave the following particulars of the value of concrete in reducing the cost of insurance:

"The large steel sprinkler tank and tower of the Victor Talking Machine Co., Camden, N.J., is an instance of the beneficial result derived from the use of concrete from an insurance standpoint. This tank holds 100,000 gallons of water, the bottom of which is 125 ft. from the ground. The total height of tank and tower is 174 ft. The diameter of the tank is 20 ft. The tower is erected on filled ground near a river, and the foundations of the four legs are supported on concrete piles.

"By reason of the close proximity of buildings belonging to other owners, the Victor Talking Machine Co. desired to take out indemnity insurance on the structure as originally designed—that is, without any concrete protection, so that in case of a fire in the buildings adjacent, and the collapse of the tower, the damage to adjoining property would be covered. This, they were informed, would cost $500 (£100) per annum. It was finally decided not to put any insurance on the structure, but instead to invest about $4,000 (£800) in fireproofing the tower with concrete. A little reflection will show that the investment fully pays for itself, not only financially, but by practically making the tower immune from fire and the destructive agencies of the atmosphere, which it would not be if left unprotected. If we charge against the tower the interest on $4,000 at 6 per cent. per annum we have $240 (£44) as the carrying charge for the absolute protection against fire, instead of a $500 (£100) charge for no absolute protection to person or property, but simply to cover any damages for which the company might be liable in case of a collapse of the tower.

"This clearly shows how it pays to carry your own insurance by taking precautions to avoid damage to persons or property by making a building fireproof. Further, the saving on the insurance premium will pay for the fireproofing in about 15 years, so that at the end of that time the original cost of the fireproofing will be wiped out. This, of course, is based on the assumption that insurance would be carried on the tower if it were not fireproofed."

Soap-Concrete.—Soap-water, instead of ordinary water, has successfully been used for the purpose of making reinforced concrete water-tight. The case is reported in *Beton und Eisen*, of January 3rd, and concerns a grain-elevator built on the Danube, exposed to inundations. The concrete was provided with two coatings, also of concrete. The outer coating, 3½ in. in thickness, consists of fine-grained concrete containing 400 kg. of cement and 120 litres of water per cubic metre of mass, and the inner layer, ½ in. in thickness, consists of cement mortar prepared with fine river sand. The water is replaced by a solution of common soft soap (potash soap), about 4 kg. of soap being added to 1 cu. m. of concrete. The building has stood one inundation well, while another building of the same material, without the soap, did not quite keep the water out. Subsequent tests were also favourable. The soap concrete is very cheap compared with other means used to render the concrete impermeable to water. The action of the soap seems to be that the lime of the cement is bound by the fatty acids of the soap.—*Engineering.*

BLAW COLLAPSIBLE STEEL STEEL CENTERING

CHEAPER & BETTER THAN TIMBER ✻ MORE EASILY HANDLED ✻ BETTER FINISH ON THE CONCRETE.

FOR SEWERS, CULVERTS, CONDUITS, ARCHES, ROOFS ETC

ILLUSTRATIONS SHOW CENTERS IN USE ON COMBINED BRICK AND CONCRETE CULVERT, FOR THE NORTH-EASTERN RAILWAY CO., AT BLYTH, NORTHUMBERLAND.

THE CONTRACTOR FOR THE WORK WAS MR. T. TELFORD GIBB.

THE BRITISH STEEL PILING COMPANY,

DOCK HOUSE,
BILLITER ST
LONDON. E.C.

Concrete Barges.—To those interested in transportation, the recent development in the use of reinforced concrete for barges is of especial interest. The history of concrete boats dates back to 1850, and the building of them is a novelty no longer, but a well-defined industry in France and Italy; while during the past year three barges for dredging purposes have been built at Panama for work on the canal there, and have fulfilled every requirement. While a concrete boat is somewhat heavier than a wooden one. it is far more economical to maintain, and, in the event of any damage to the hull, any necessary repairs can be cheaply and quickly effected, as some filling in with cement or concrete is all that is required. Comparative estimates have been made of the first cost and maintenance of boats of wood and concrete, and it has been found that whereas a wooden barge, after five years' work, requires repairs involving an expenditure of about 30 per cent. of the first cost, the concrete barge, after eight years' service, is in good condition. In any class of work necessitating the use of barges, and where low first cost and maintenance charges are the primary considerations, reinforced concrete boats will be found worthy of attention.—*Iron and Coal Trades Review.*

Monolithic Concrete Buildings.—The American Sheet and Tin Plate Co. at Gary, Ind., are to erect about 200 dwelling-houses for their workmen at Gary in connection with the construction of a new plant. Monolithic concrete construction will be employed, and the buildings will be built in steel forms manufactured by the Reichert Manufacturing Co., Milwaukee, Wis. These forms consist of 24-in. panels of No. 16 galvanised steel plate, with the edges reinforced by a 1-in. by 1-in. angle, and each panel is provided with a lock for fastening it to the adjacent panel or to the corner connections. Opposite panels of the inner and outer forms are held together by wire ties, and at the top of the forms transverse stay rods, hooked over the flanges, are employed. During the past five years these forms have been used extensively in Milwaukee, and those first employed are said to be in good condition now. Cores can be inserted to make hollow walls or flues, and interior strips can be fitted in place to give the wall a block appearance with bevelled grooves. Door and window frames are set in place in the forms. Where the dimensions make it necessary special sizes of panels can be used.

At Gary the forms for the foundations, basement walls and partitions, and the first-floor slab will be set up for about a dozen houses at once. A portable concrete mixing machine, with a hoisting plant, will run on a track parallel with the row of buildings, and the entire amount of concrete needed to fill these forms will be poured at one operation. When this work has been completed at one building the machine will be passed on until the entire row is completed. By this time the concrete in the first building will have set so that the forms can be removed and re-erected for the first-floor walls and partitions and the second-floor slabs. The machine will then be run back to the head of the line, and the process repeated for this set of forms. A third trip will complete the pouring for the second story and the roof.

It is expected that the cost of these dwellings will be less than that of frame structures, owing to the very small amount of labour and skilled work required; but it is stated that even if the cost should be 12 to 20 per cent. more, the saving in repairs, repainting, and reduced insurance rates should balance the increase in the first cost.—*Times Engineering Supplement.*

The Permanent International Association of Navigation Congresses, which will hold its twelfth meeting at Philadelphia in the spring of 1912, has appointed Mr. R. W. Vawdrey, B.A., A.M.Inst.C.E., to prepare a report upon the work which has recently been carried out in the United Kingdom in reinforced concrete as applied to hydraulic works.

Communications on this subject from engineers who have used this form of construction in the direction mentioned should be sent to Mr. Vawdrey, Queen Anne's Chambers, Westminster, who will be glad to incorporate these particulars in his report.

Test on New Type of Hollow Tile Floor.—The Considère Construction Co., Ltd., have recently designed a new type of hollow tile floor on the principle of continuous beams, and, as a test, have had two spans of 15 ft. running over a centre support made and loaded with glazed bricks. This preliminary test was made only 24 days after the manufacture of the slab, and was carried out in the presence of a well-known architect and a member of a prominent firm of builders, who were so satisfied with the result that the floor has been adopted for a large office building shortly to be erected in London. The final test on the slab will be made to destruction in some few weeks' time.

CONTRACTS.

Messrs. James H. Tozer & Son, Ltd (Lock Woven Mesh System), have secured contracts for erecting a single coal bunker of 300 tons capacity, and a water tank for 50,000 gallons; also walls and floor to the power house for the Skinningrove Ironworks Co., Ltd., Yorks; also floor for Stable at Silverdale, and floors at Montrose, Torquay, and Birkenhead.

The British Joist Steel Piling Co. inform us that in connection with the building of the new Cunarder, which, when finished, will be the largest ship in the world, a new berth is being constructed at Messrs. John Brown & Co.'s Shipyard, Clydebank, and the British Steel Piling Co. have secured the contract for their "Universal" Joist Steel Sheet Piling required in this work.

"BIC" BRITISH "BIC"
IMPROVED CONSTRUCTION CO., LD.
TELEPHONE: 4067 VICTORIA. TELEGRAMS: "BICONCRETE, LONDON."
47 VICTORIA STREET, WESTMINSTER.

Flat-based Concrete Pipes
Three feet long to Nine feet long.

Breeze Partitions
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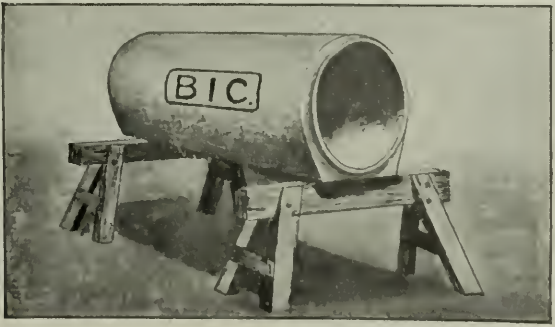
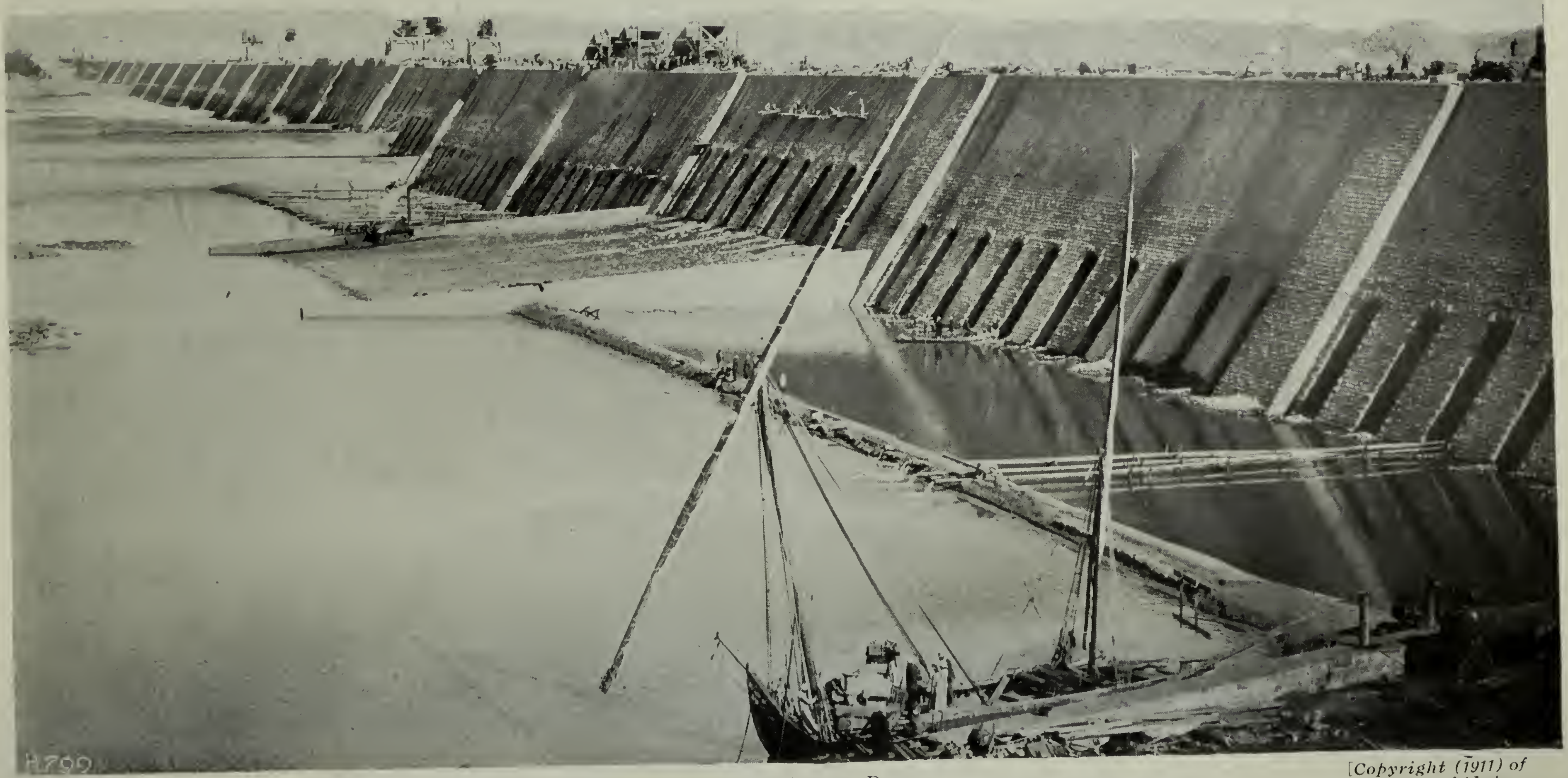


Porous Pipes
Concrete Beams
Hollow Floors

SPECIALITY:—INVENTORS' DESIGNS CARRIED OUT TO ORDER.



THE ASSOUAN DAM.

General view of the Dam as recently thickened on its down-stream face, and now being raised.

Note: See three Cement Grouting Machines on Dam.

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CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

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EDITORIAL NOTES.

THE COST OF SCHOOL BUILDINGS.

WE have made numerous references in these columns to the waste of public money on building and engineering works, owing to the conservative methods of the Local Government Board. Local authorities are constantly spending more than necessary in order to comply with the requirements of that department, and those requirements take little or no account of modern building methods or the introduction of new materials.

The latest evidence as to the waste of money occasioned through antiquated regulations will be found in the report of the Departmental Committee of the Board of Education, which has been inquiring into the cost of school buildings. We are dealing with this report more fully in another part of this issue.

The committee state that they were embarrassed in their inquiry by the small number of buildings erected on novel lines, which would enable them to judge how far the methods and materials employed are really suitable for school purposes, and they go on to say that :

> The scarcity of experimental school buildings is attributable partly to the natural preference by architects for materials and methods with which they are thoroughly familiar, and which require comparatively little supervision of the work in course of erection.
>
> It is also attributable to a great extent to the fact that the Building Regulations of the Board of Education do not contemplate, and do not encourage, experiment in novel materials or methods.

The committee are, therefore, of opinion " that the existing obstacles to experiment should be removed." This sentence puts in a nutshell the position taken up by certain prominent architects and others respecting the restrictions of the by-laws, which have up to the present been framed to discourage inventors and prohibit experiments.

Reinforced concrete as a method of building was invented by an Englishman as far back as 1853, but undoubtedly the reason why we never reaped the full advantages of this method of construction was due to this conservatism and restrictive action of public bodies. It was left to foreign countries to develop this industry. When it had become an actual success and came into prominence, it was brought back again to this country and exploited as far as possible; whereas we had the whole matter in our hands from the beginning, if we had only been able to deal with it in the proper manner. It is, therefore, very important to find a Government department emphasising the desirability for experimenting with new materials and new methods.

The recommendations of the committee are worthy of special mention, and are as follows:

> (1) That local education authorities should be encouraged to submit specific proposals for the use of novel materials or methods for public elementary schools.
>
> (2) That it should ordinarily be made a condition of the approval of such proposals that such provision as is practicable should be made for the periodical inspection of the structure.
>
> (3) That, for the purpose of facilitating the use of novel methods and materials, (*a*) legislation should be promoted to exempt school buildings, the plans of which have been passed by the Board of Education, from the operation of local building by-laws and corresponding provisions in Local Acts; (*b*) the building regulations of the Board of Education should be revised so as to remove any difficulties placed by them in the way of the adoption of such methods or materials.
>
> (4) That, where proposals are approved for the use of novel methods or materials, such as those described in paragraphs 27 to 54, in the erection of permanent schools, a loan period of 30 years should, until further experience is available as to the durability of such structures and their immunity from repairs, be regarded as normally appropriate to such cases.

It is time, indeed, that local authorities should be relieved of the dead weight of expenditure due solely to the antiquated ideas of a few Government officers, and it is to be hoped that the report now before us will eventually open the eyes of Parliament as to the lack of interest in true municipal economics still to be found in certain directions.

THE RUSTING OF STEEL IN CONCRETE.

Draft Report of the Science Standing Committee of The Concrete Institute.

SOME time ago the Science Standing Committee of the Concrete Institute formed a sub-committee for the purpose of investigating the very important question of whether rusting of steel takes place when inside a concrete covering. A letter was issued at the beginning of 1909 by the Institute to all its members and to others engaged in concrete construction, asking for the results of their experience of this matter. A summary of the replies received and of the conclusions arrived at by the Science Standing Committee form the subject of a draft report which was read by Mr. F. E. Wentworth-Sheilds, M.Inst.C.E., at a General Meeting of the Institute held on March 9 last.

The sub-committee have also personally examined certain structures and the results of their examination form appendices to the report. An account of their visit to Paris in April, 1910, in this connection will be found in our issue of June, 1910.

As a result of these observations and investigations, the Committee have drawn the following conclusions :

> Reinforced concrete will last as long as plain concrete in any situation provided that special precautions are taken during its construction. The precautions to be taken are as follows :
>
> ***Concrete.***—The materials (cement, sand and stone) must be of good quality. They must be most carefully and thoroughly mixed and scientifically proportioned, so as to be practically waterproof and air proof. The mixture must be fairly wet, and must be well punned into position so as to minimise voids. The aggregate should be as non-porous as possible, and any aggregate which is known to have a chemical action on steel should be avoided. The aggregate should all pass through a $\frac{3}{4}$-in. mesh. The concrete covering should in no case be less than $\frac{1}{2}$ in., and it is suggested that if round or square bars be used the covering should not be less than the diameter of the bar. In structures exposed to the action of water or damp air, the thickness of covering should be increased at least 50 per cent., or the size of the aggregate should be reduced so as to ensure a dense skin. In the case of structures exposed to very severe conditions, the concrete might be covered with some impervious coating as an extra precaution.
>
> ***Steel.***—The reinforcement should be so arranged that there shall be sufficient space between one piece and its neighbour to allow the concrete to pass, and to completely surround every part of the steel. All steel should be firmly supported during the ramming of the concrete, so as to avoid displacement. It should not be oiled or painted and thick rust should be scraped and brushed off before placing.
>
> ***General.***—The scantling of the various members of the structure should be sufficient to prevent excessive deflection. If electric mains are laid down very great care must be taken that no current is allowed to pass through the reinforced concrete. Fresh water should be used in mixing, and aggregates charged with salt should be washed.
>
> These recommendations have regard only to the prevention of corrosion of steel, and not to fire resistance or any other property of reinforced concrete.

COKE BREEZE AGAIN.

In our issue of January, 1911, we published an extract from Mr. Thomas Potter's able paper on "Concrete Practice," and we would now specially call attention to his views on coke breeze. Coming from the *doyen* of the concrete industry, an opinion, based on many years' experience, merits close attention. For our part we agree with Mr. Potter. The wholesale condemnation of coke breeze is quite uncalled for. To condemn an excellent material because in a few instances poor stuff has been used or unsuitably applied is as senseless as, say, to condemn reinforced concrete because the material is not invariably properly applied.

We give Mr. Potter's views in full :

> There is one aggregate many thought beneath notice—coke breeze. It was extensively used for many years, principally for floors, but, I submit, undeservedly lost its character some time since through a letter in the *Times* telling of its failure in Germany, where it had been prohibited. It was not stated, I believe, of what class of coal it formed the residue, and this is an important point. I have seen some in Scotland totally unfit for concrete purposes, but not in England. This letter was followed by others telling how it was of such an inflammable nature, that if exposed to a severe fire it was second only to coal in assisting combustion. Another letter

stated that it disintegrated in the course of a few years and crumbled away. It was a case, I think, of giving a dog a bad name.

So far as its strength is concerned, Mr. Kirkaldy made some experiments for the West Ham Corporation some years since, with the following result : A brick pier 18 in. square, and 18 in. in height, made with best stock bricks and blue lias lime mortar, crushed at the end of two years with 46 tons per sq. ft. ; a similar pier of Harold Wood bricks and blue lias lime mortar crushed with 75 tons per sq. ft. ; another pier, made of six parts of coke breeze to one part of Portland cement, crushed with 131 tons per sq. ft.

As to inflammability, the tests made by the Fire Prevention Committee with various kinds of floors, each under similar conditions exposed for three hours to an increasing and ultimate temperature of 1,900 deg. F., and water played on them from a hose pipe, gave the following results :

Coke breeze and burnt ballast equal and best ; each was found, after being allowed to cool, practically free from cracks or deflection, and Thames ballast and granite chips the worst.

As to disintegration, this would not be readily ascertained perhaps with floors, which are usually plastered on the underside and covered with some other material on the surface, but much of the facing and all the ornamental work of the large block of buildings numbers 64 to 70 Victoria Street, are of cast coke breeze concrete, executed about forty years ago by the late Mr. W. H. Lascelles, of Bunhill Row, London. No facing was done to this work after it left the moulds ; the coke breeze is within an eighth of an inch of the surface, and I believe there has never been a crack, fracture, or any sign of disintegration at any time.

I wrote some years since to the clerk of works of a large building to inquire concerning a number of floors made with coke breeze concrete, more especially as to whether there had been any expansion. His reply was : " A number of the pavilions are 120 ft. long and 26 ft. wide, without a break or a division wall, the ground floors being 5 ft. in height from the ground, and the upper floors 14 ft. above the ground floor. Had there been any expansion, it must have shown before this, as most of them have been done four years, and I may add that the floors give every satisfaction."

I have used some thousands of tons of coke breeze for floors, and do not remember a failure of any kind therewith. I am aware that coke breeze is condemned by many as an unsuitable aggregate. I can only speak from my own experience ; and although it is not, taken altogether, the best material for floors and roofs, I have found it one of the best. But like other materials there are good, bad, and indifferent qualities. I have known ashes from dust-holes to be mixed with it.

PROPORTIONING CONCRETE.

It is rather surprising to find so little attention paid by those who often pass for experts to the proportioning of the ingredients of concrete. This applies not solely to reinforced concrete, but to concrete generally. The great thing to strive for is density in the mixture, and the aggregate and the sand should be so graded as to obtain a minimum of voids. It is possible with a very weak proportion of cement to obtain a very dense concrete by proper grading. The cement, it must be remembered, has to serve the function of filling the voids in the concrete, and consequently the overplus from the voids, if any, will, according to its amount, increase the strength—that is to say, provided we have filled the voids, the proportion of cement which is over therefrom will give the compressive value to the concrete. If, however, the voids are not completely filled, the concrete must be somewhat porous in structure and weak. The most important feature, therefore, in the manufacture of any concrete is to see that the voids are as completely filled with the aggregate as possible ; the cement then need only be sufficient to fill the remaining voids and to coat the particles with as much as may be needed to give the required strength, the desired strength being ascertained with regard to economy, waterproofness, and other qualities.

GRADING OF AGGREGATE.

We know that instead of the 6 : 1 lime concrete, which was often favoured in the past, a 15 : 1 mixture of Portland cement and aggregate is quite as good ; but little attention is paid to the question as to how the aggregate in such a mixture should be graded. It is possible to make a difference of 100 per cent. or more in the crushing resistance by attention to the matter of grading. If the aggregate is composed of particles all of one size, the amount of voids will be about 50 per cent. ; if it is composed of two sizes of particles, the proportion of voids will shrink to between 30 and 40 per cent. ; by still more variation in the size of the particles, it is possible to get the amount of voids down to 20 to 25 per cent., and in a very weak proportion such as 1 : 15 there is no reason why one should not include an amount of fine sand so as to reduce the percentage of voids still lower. It is not always the use of a lot of sand which will so reduce the percentage of voids, because sand, which is composed of a fairly regular form of grain, will likewise contain 50 per cent. of voids. A gradation of size is necessary in either large or small material in order to reduce the amount of voids, it being the gradation in size which enables the particles to arrange themselves more closely together and leave a smaller proportion of interstices. It is easy to see that if we have a properly graded material wherein the voids are a minimum, the cement will go much further and the concrete will be denser and stronger. The principle applies equally to a poor concrete such as 15 : 1, or a rich mixture such as 1 : 1 : 2 (*i.e.*, 1 : 3).

Of course, the aggregates that are accessible in various parts of the country differ in kind, and they also differ in physical constitution. For many purposes the aggregate is crushed, and then there is not so much difference in the material as would be otherwise found by reason of the difference in locality from which it is derived, but for much ordinary concrete work the aggregates are used just as they are obtained, with only a small amount of sieving or screening to remove the large pieces. We may here remark that screening, entailing some expense, is often done that is unnecessary, because the material may be graded while in its natural state, and if there is an insufficiency in one portion of the material, it is better to supplement this by adding an amount of the one or more ingredients to make the total correct, than it is to screen out the material and add the various portions together to give the desired mixture.

NECESSITY FOR SCIENTIFIC INVESTIGATION.

A little attention paid to these points will give much better quality in work, and result in considerable economy. Of course, in the preliminary stages of estimating one is not able to go into such refinements ; but when a job has been obtained such data should be found for a scientific proportion of the concrete, and such information would, of course, once ascertained, be available for future reference. Work of this nature ought to be undertaken by somebody, and the results issued to serve generally to assist the whole of the architectural and engineering professions and the building trade, but at the present time it seems unlikely to expect such work to be done by a Government body or society. We think it desirable to emphasise, however, that such work is of great and material importance to the contractor and the concrete specialist, and, as we remarked before, it is surprising that more is not done in such investigation. A few pounds spent in this way would save a great deal of money on many jobs ; hardly any job is too small but some slight investigation would repay the cost. Really a scientific study of the proper manufacture of concrete has not been conducted by experts, who, one would think, would have given attention to it. It is not a matter of pure science either, for the immediate economy obtainable by such investigation has been so often proved that it would be more charitable to lay the blame for this indifference upon the fact that the experts are busy studying other commercial aspects of the business. The manufacture of cement has progressed greatly these last few years, but the understanding of how to make good concrete has not advanced in equal degree ; to a great extent we still remain in the " dark ages " of concrete.

THE CONCRETE INSTITUTE.

The next ordinary general meeting of the Concrete Institute will be held at Denison House, 296 Vauxhall Bridge Road, Westminster, on Thursday, April 6th, 1911, at 8 p.m., Sir Henry Tanner, I.S.O., F.R.I.B.A., presiding, when Mr. C. Percy Taylor will read a paper entitled " The Reinforced Concrete Pier at Swanscombe," to be illustrated by lantern slides.

A Students' Section is being established in fulfilment of one of the chief objects of the Institute—namely, to advance the knowledge of concrete and reinforced concrete and their constituents, and to direct attention to the uses to which these materials can be best applied. In further extension of this policy a course of educational lectures on the subject of " Reinforced Concrete " is being arranged for students and the public ; these will be given on six consecutive Wednesdays, commencing April 26th, at 5.45 p.m., and occupying approximately one hour, the lecturer being Mr. R. W. Vawdrey, B.A., Assoc.M.Inst.C.E., M.C.I. Admission will be free, by ticket obtainable on application to the Secretary.

The Concrete Institute has made progress during the last year, its membership having increased by 55. It has reported on a number of technical subjects, and it has been consulted on various matters by public authorities, societies, and others.

The offices of the Concrete Institute have been removed from 8 Waterloo Place, S.W., to Denison House, 296 Vauxhall Bridge Road, Westminster, S.W., and their telephone number is now 2112 Victoria. The new offices will be more accessible to the majority of members, and will give increased accommodation. A library and reading room will be formed for the general use of the members, while the advantages obtained by holding general meetings in the same building are apparent.

THE RAISING OF THE ASSOUAN DAM.

The completion of the Assouan Dam was one of the greatest works of our times. The raising of the dam means not only the improvement and extension of a fine piece of civil engineering, but also innumerable additional benefits for a country for the prosperity of which we are largely responsible. The work is proceeding rapidly and the raising will be completed two years hence. The following notes, written on the spot and illustrated by excellent photographs, should be of interest to all civil engineers and those concerned with the use of Portland Cement Concrete in particular.—ED.

WHEN the Assouan Dam is mentioned in engineering circles at home, its importance, dimensions, and the technical difficulties surmounted are invariably described as "very great," yet no one who has not actually seen the structure can realise its remarkable value, its magnitude, or its position as one of the great engineering wonders of the world. Drawings, photographs, and figures do not, and in fact cannot, properly express the character of this great dam. It requires the visual and mental observation of both the work, its location and its utility, to fully comprehend its magnificence.

That this great work should have been conceived and executed by British engineers and contractors will stand to our lasting credit, no matter what our position in the world's engineering may be in other directions.

If the Assouan Dam, as originally built to control the waters of the Nile be a magnificent achievement, we venture to think that the present work of raising its height some further twenty odd feet must likewise rank as an undertaking of the highest order, and in certain respects we consider the engineering difficulties that have to be overcome not a whit less important than those surrounding the completion of the original structure.

Expressed briefly, the original dam accumulates 234,000,000,000 gallons of Nile water for irrigation purposes, by which means about half a million acres of land have been rendered cultivable. The dam runs 2,150 yd. across the Nile, rises 130 ft. above its foundation, has a width of 23 ft. at the top, and 180 sluices. The additional height will mean water storage 2½ times that of the present enormous amount, and close upon another million of acres rendered arable.

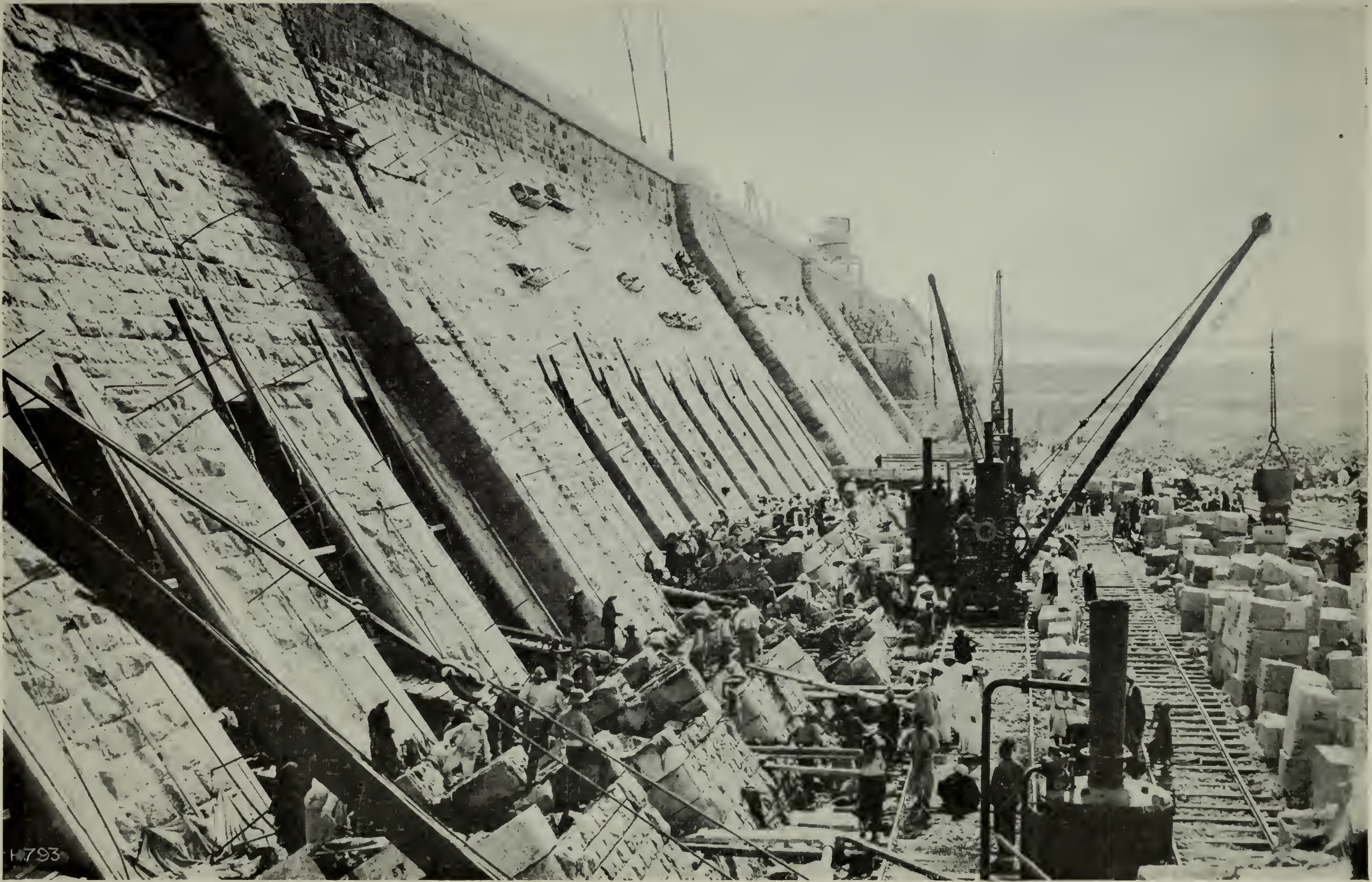
In order to attain this additional storage capacity, the dam is not only being raised about 23 ft., but it is also being thickened, this comprising an additional 16 ft. taken down the face to the foundations and firmly bedded into the great aprons that prevent erosion at the foot of the dam. Some three years' work on this strengthening of the dam has already been done, and another two years' on the raising of the structure will probably mean completion sufficiently early in 1913 to obtain the additional water storage for that year. Some special views of exceptional interest presented in these pages illustrate the current work in progress.

The primary difficulty has been the joining up of the new work with the old, and in this Portland cement has played an all-important part, the joint between the old work and the new being about 6 in. wide, close upon 100 ft. high, and fully 2,000 yd. long, this length, however, being divided into sections. A liquid grout is used. It is mixed in three large mixers and carefully run in through metal flexible hose, loose stone (of under 2 in.) having been left in the joints to serve as aggregate, and the grouting taking place when the temperature of the new work and the old is approximately equal. The means by which this grouting is effectively and carefully done, the records showing the temperature of the new and the old work, the mixture of the grout, and the reasons governing the adoption of the precise mixture used, are all matters of the greatest possible interest, and when the work has been completed, they will be the subject of papers by the Director-General of Reservoirs, Mr. Macdonald, C.M.G., whose thoroughness in the collection of reliable data on matters of this kind is one of the great assets of the engineering profession. In the meantime, it should be mentioned that the scheme applied for this complex work is excellent, particularly having regard to local climatic conditions and the cosmopolitan staff of workers and foremen.

Of the supplementary works in connection with the raising of the dam, we would mention the extension of the series of locks to take the Nile steamer traffic—this extension involving a strengthening of the locks generally, an additional gate some 80 ft. in height, and a clever re-arrangement of the existing lock gates. Here, again, when the work is completed, the design and programme of execution will merit a paper for the information of the engineering profession, for the difficulties to be surmounted were considerable, and the time limit by no means liberal.

For those concerned with concrete, the work at the dam has the peculiar interest of being a gigantic example of the application of Portland cement concrete and Portland cement generally. British Portland cement has been used throughout, and in the present work—which involves an expenditure of a million and a half sterling—a large part is from the works of the Associated Portland Cement Manufacturers, Ltd. The responsibility of providing a perfect cement at such a distance from the Thames for use in a climate of exceptional dryness and high temperature should not be underrated, the more so as the slightest hitch in the quality of the material may at any moment involve a very heavy expenditure of time and money in the pulling down and re-erection of the work, seeing that not the slightest of risks can be taken in the execution of this great undertaking. The old aeration method, by the bye, is very wisely not adopted at Assouan. The cement reaches the dam aerated and ready for use; the absurd natural aeration, against which Mr. Bamber recently lectured before the Institution of Civil Engineers, is not practised in this up-to-date engineering field.

This article, as already indicated, is not intended to present the technical details of the raising of the dam, but the illustrations are of sufficient clearness to show some of the features of the work. The position of the great joints, the pipes for pouring down the grout into the joints, the horizontal inspection and test pipes, the bars used between the new and the old work, all show distinctly

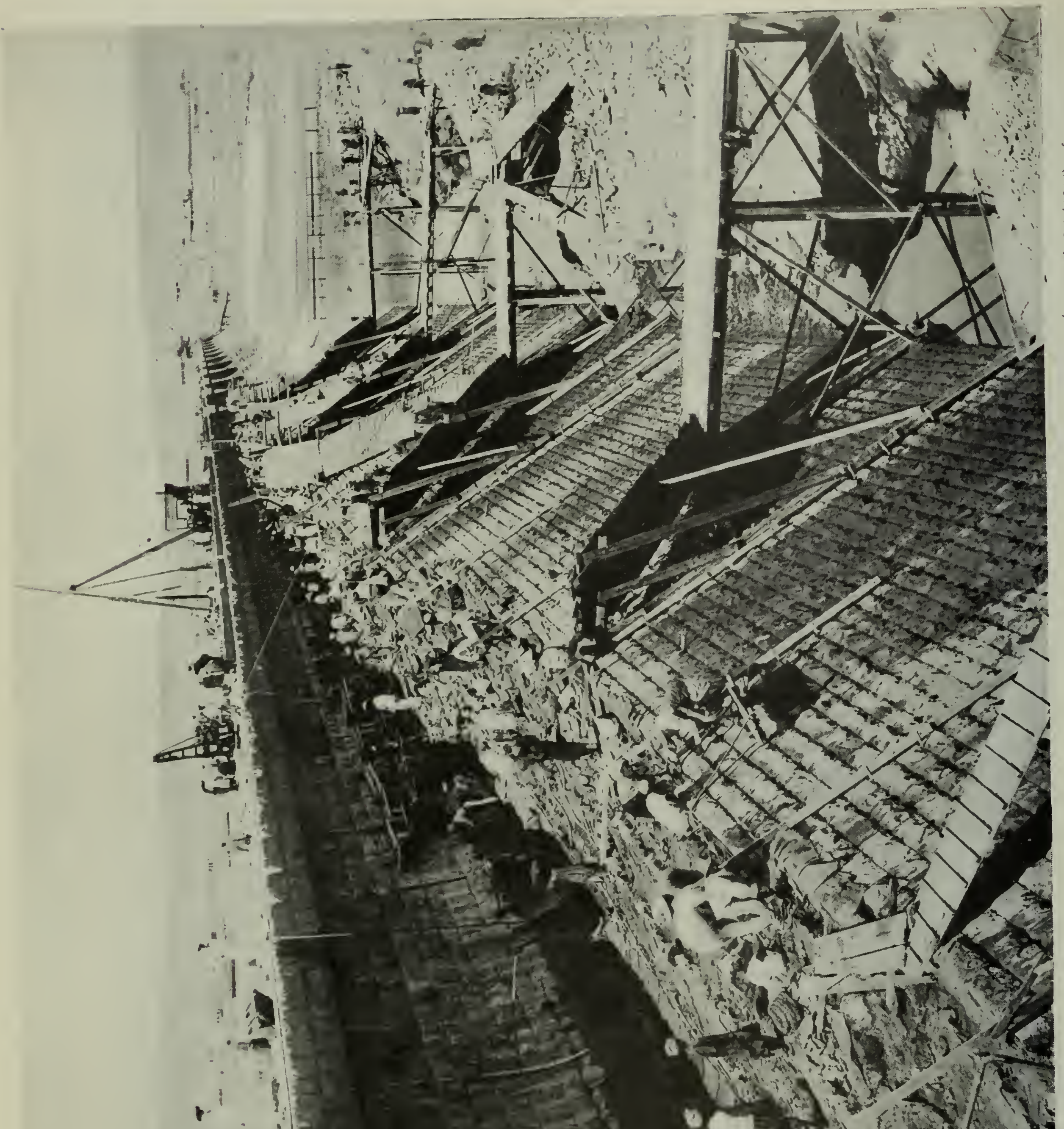


(Copyright (1911) of owners of the plate.)

The Assouan Dam.

View of lower courses of thickening being applied on down-stream face.

Note: See rods for connecting new work to old; see perforated pipes on slope between sluices for applying cement grouting to the 6-in. joint; see inspection pipes on face of new work for controlling grouting operations.



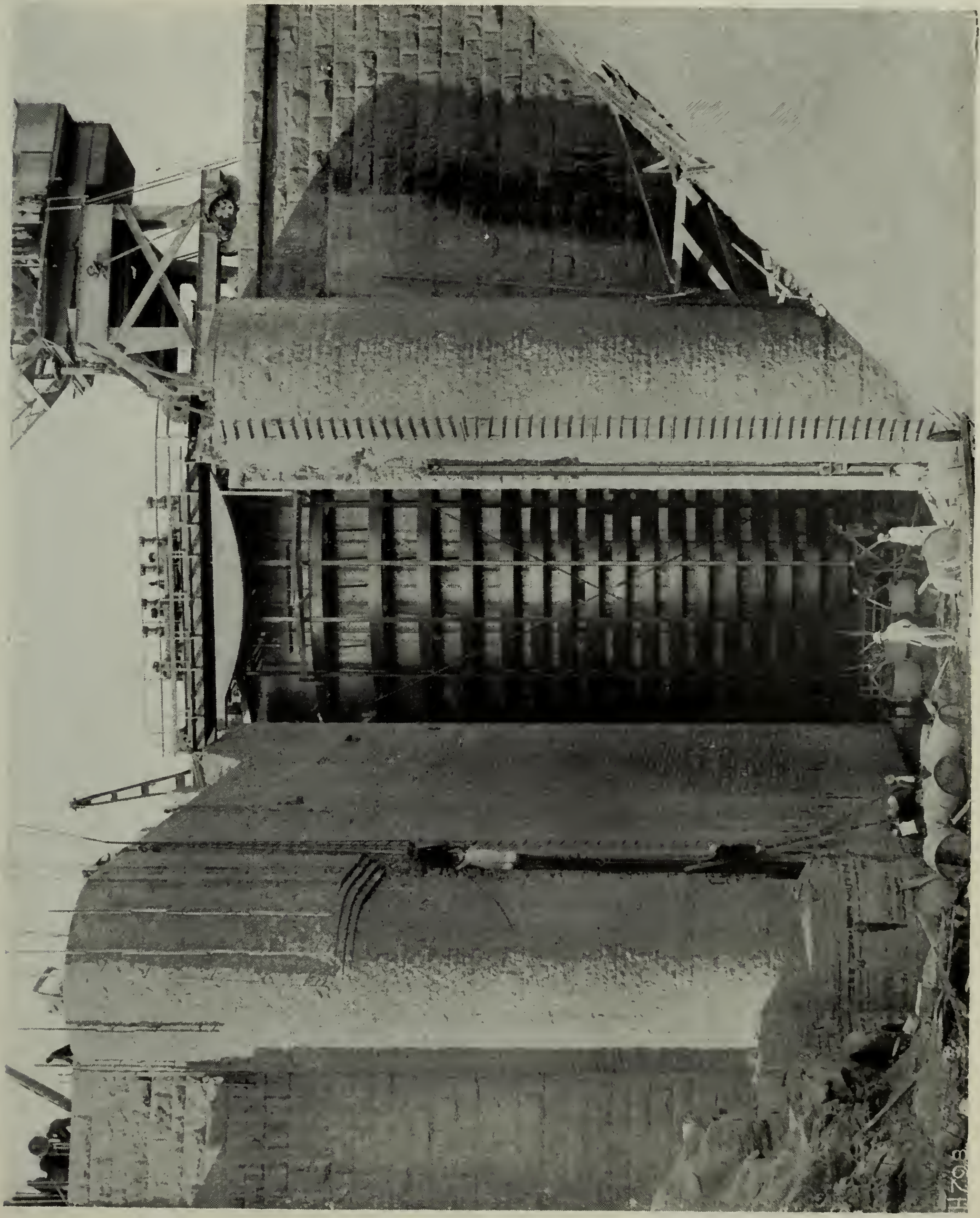
THE ASSOUAN DAM.

View of thickening on down-stream face nearing completion.

Note:—See same constructional features as in previous illustration. The thickening is 16 ft. wide.

(Copyright (1911) of owners of the plate.)

on the photographs reproduced. Likewise, the difficult masonry around one of the sluices, the type of grout mixer, the great lock gate, etc., are clearly indicated. In one respect, however, the photographs quite fail to give the correct impression, and that is, as indicated above, in the matter of size and scale. Photography cannot fully assist the reader in this direction.



THE ASSOUAN DAM.
View of the up-stream entrance to the series of locks.
(Note: The lock gates are about 80 ft. high.)

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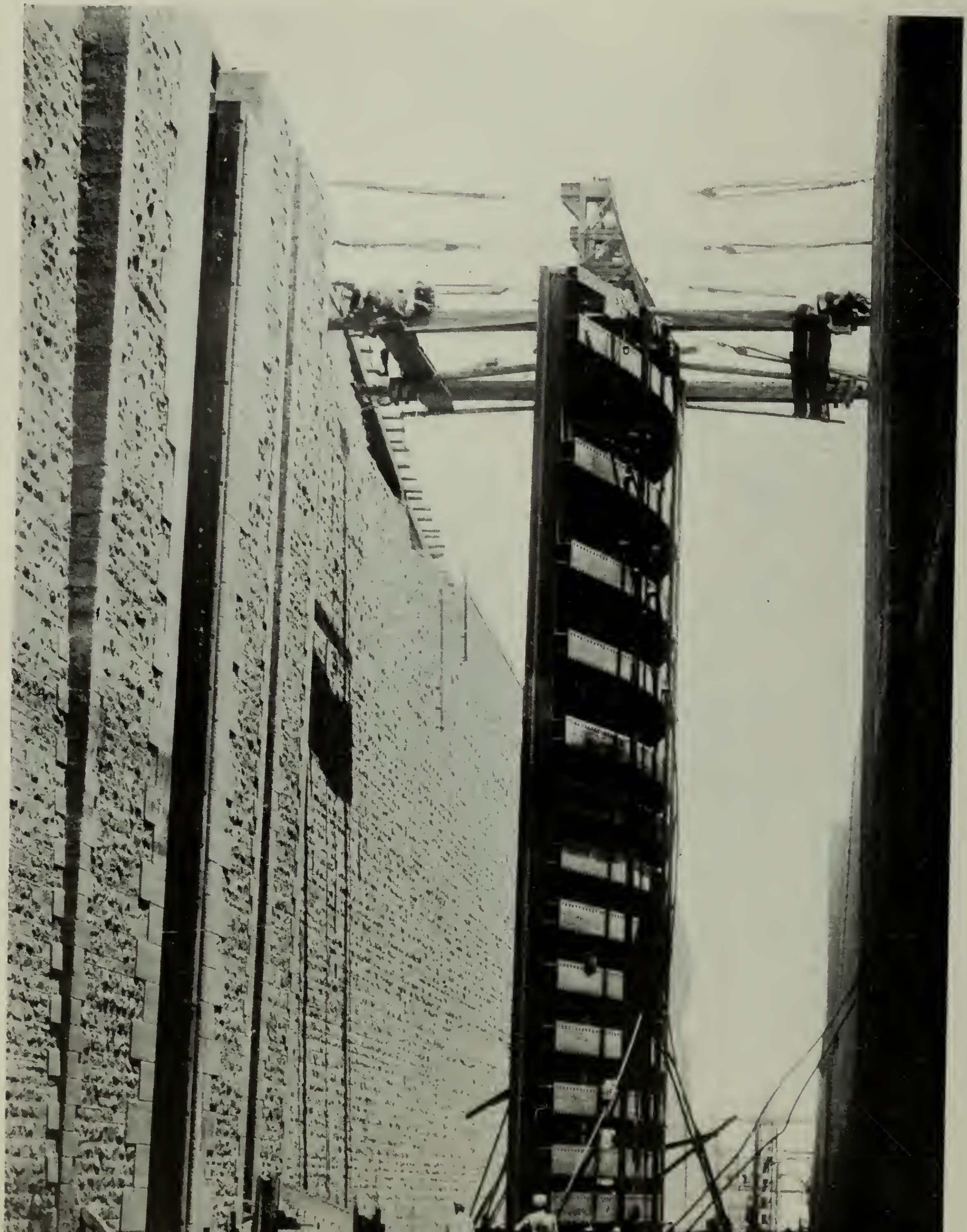
As to the responsibility for the work now in hand, it must be divided between the late Sir Samuel Baker, Sir William Garstin, and Mr. M. Macdonald, yet as a matter of fact it is the latter on whose shoulders rests much that relates to the design and everything concerning the execution of this undertaking. In this execu-



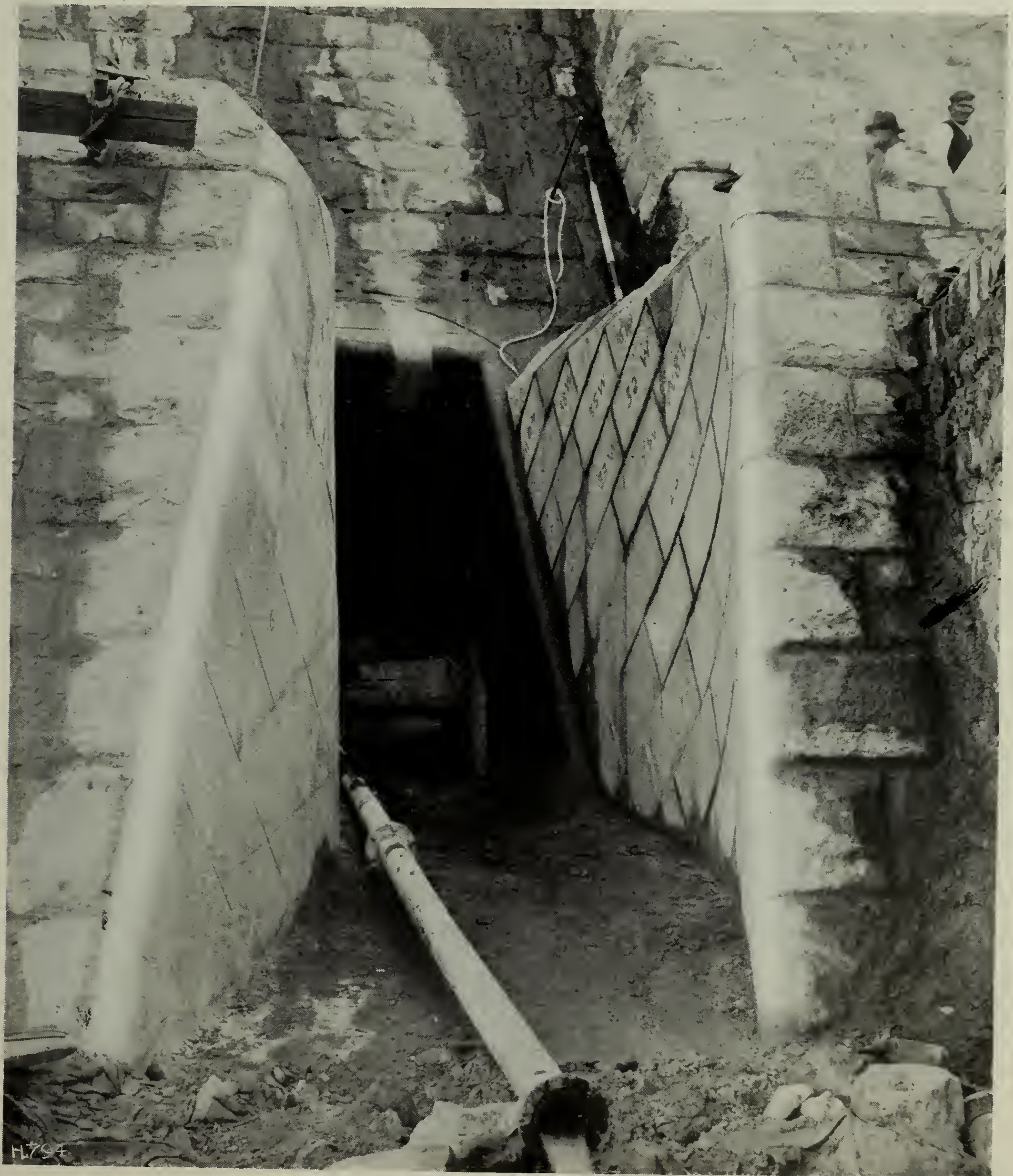
THE ASSOUAN DAM *(Copyright (1911) of owners of the plates.)*

View of one of the lock gates (No. 2) being put into position.

(Note: The view is taken from the South entrance of the series of locks, i.e. looking down stream.

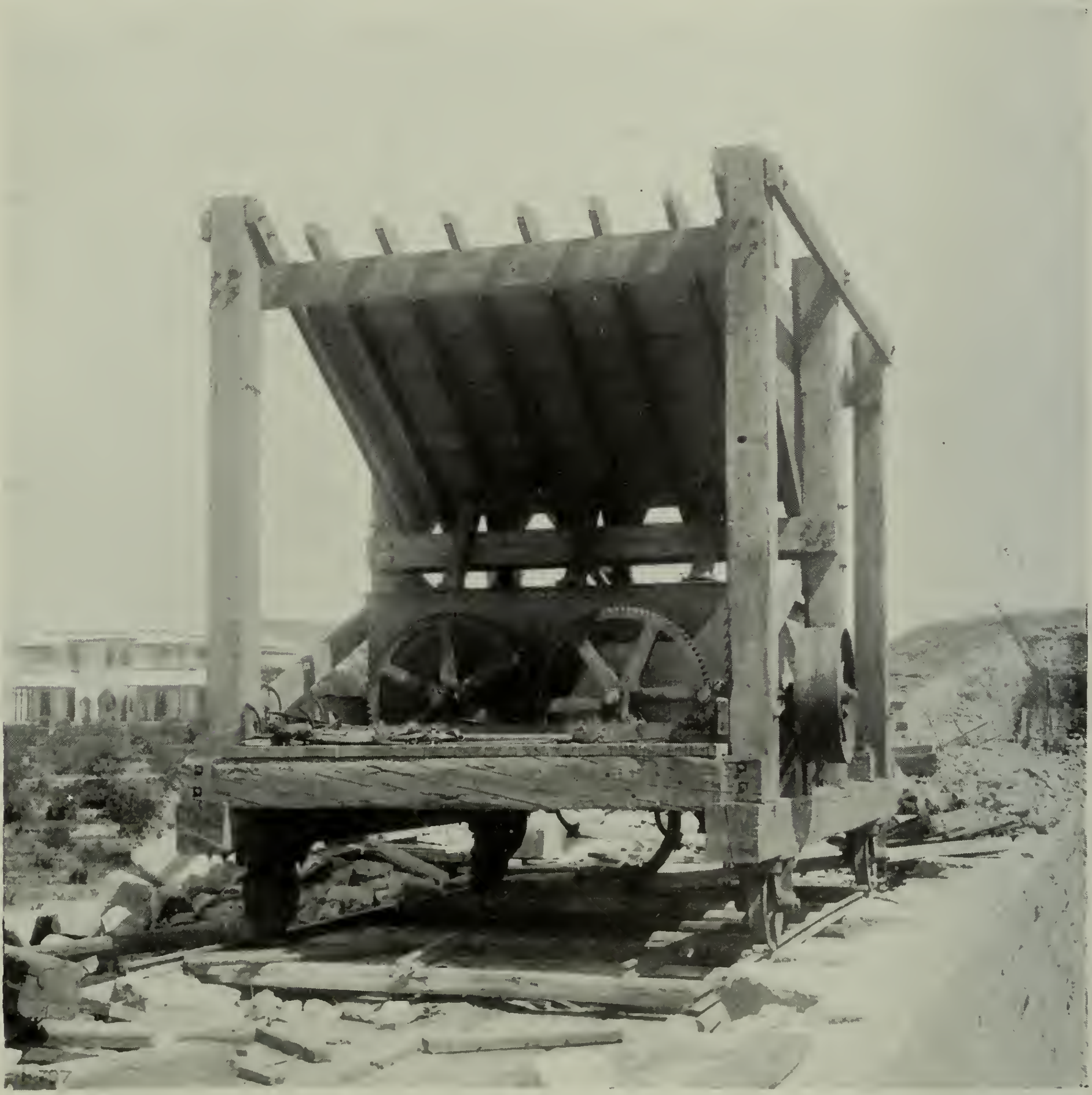
tion, Mr. Macdonald is supported by Mr. McCorquodale and an enthusiastic staff of civil engineers largely hailing from Scotland.

The contractors for the dam proper are Messrs. John Aird & Co., and Messrs Ransomes & Rapier are providing the ironwork. The contractors, it should be added, appear to be doing their part well, and there is an absence of that friction which has unfortunately been a feature of some of the great engineering contracts at home. That this smooth working prevails has, we think, been largely due to the concise and clear form of the specifications and instructions, and the constant supervision of the smallest features of the work.



THE ASSOUAN DAM. *(Copyright (1911) of owners of the plates.)*
An interesting piece of double-curved granite masonry on the thickening of the down-stream face (Sluice No. 1, Set 1)

We would like to deal with other technical and administrative features of the raising of the dam, but we fear to record matters prematurely before its completion, and to describe features which should in the first instance be dealt with by those who are responsible for the work. What we know of the undertaking, both of its main features and the many supplementary or allied circumstances, all tends to show that we have before us not only a great engineering work, but technical management of unusual excellence. The raising of the Assouan Dam is one of the few pleasurable instances of the successful handling of modern civil engineering, where every department and side-issue merits praise, and we trust the perfection of the work and its moderate cost will be duly appreciated by the members of the technical professions at home.



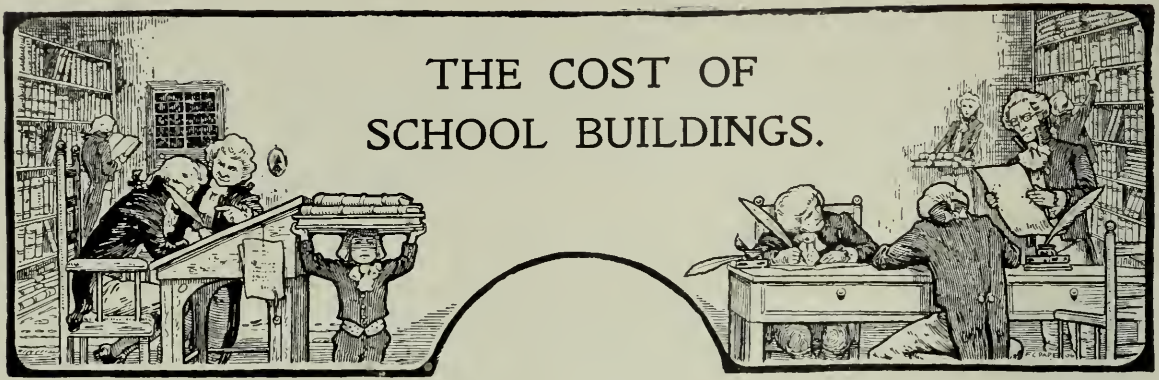
THE ASSOUAN DAM (*Copyright (1911) of owners of the plates.*)

One of the three large cement grout mixing machines.

There is one additional word we would like to say to architects, archæologists, and artists. The dam, by its look of utility and power, has all the features of a great work of art. The bold, straight line of plan, the curved front, the sluices with their well-regulated streams of foaming water, all speak forcibly of a well-conceived purpose well executed with the least possible waste of material and the least possible superfluity of strength. As perfect manhood is beautiful, so is the Assouan Dam, and those who write to the contrary do not know what beauty means.

Finally, one word to these critics as to the submersion of the Temple of Philae caused by the raising of the Assouan Dam. This temple is one of many ruins situated between Cairo and Wadihalfa, and although the temples as a whole are of the greatest possible interest, the single specimen is a mere entity. What each entity is able to teach the present age has been investigated and recorded, and these records are duly housed within easy reach of students. Whether one or a dozen of the ruins disappear to-day is merely a matter of sentimental regret. The practical loss would be nil, for there is no utility in the ruins, and all they have to teach us has been duly taught. To demand that the possible submersion or occasional submersion of one or more ruins should stand in the way of the development of Egypt is as unreasonable as it is inhuman. Humanity requires that our knowledge, skill, and means be applied to the improvement of mankind. The lot of the Egyptian is vastly improved by the regulation of the Nile. With the increased prosperity of Egypt, funds become available for better hygiene and sanitation, for the reduction of eye-diseases, for elementary education and for general civilisation, and it is absurd to expect that all such benefits should be prevented or retarded for the sentimental views of egoistic art-lovers who for the most part know little and care less for Egypt. We work for the future. The past is very well cared for.

THE COST OF SCHOOL BUILDINGS.



In February, 1910, a committee was appointed by the President of the Board of Education to inquire into the cost of School Buildings, and was constituted as follows :

Mr. L. A. Selby-Bigge, C.B., Principal Assistant Secretary of the Elementary Education Branch of the Board of Education (Chairman).
Mr. N. T. Kershaw, C.B., Assistant Secretary of the Local Government Board.
Mr. F. Clay, Architect of the Board of Education.
Mr. J. G. Milne, Senior Examiner of the Board of Education, to act as Secretary.

The committee were to report on the following :

(*a*) Whether the cost of buildings for public elementary schools can properly, and with due regard to their suitability and durability, be reduced by the use of materials or methods of construction different from those ordinarily employed at present ; and, if so,

(*b*) What steps should be taken to facilitate the adoption of such materials or methods, and whether any alteration in the law is required for the purpose.

The committee held sixteen meetings, examined thirty witnesses, and visited buildings at Anerley, Ipswich, Bordon Camp, Harrow, Borstal and Windsor for the purpose of investigating novel methods of construction. They communicated with the Councils of the Royal Institute of British Architects, the Royal Sanitary Institute, the Land Agents' Society, the Surveyors' Institution, the Quantity Surveyors' Association, the Institution of Civil Engineers, the Association of Municipal Corporations, and the County Councils' Association ; also with the War Office, Admiralty and Home Office.

Before dealing with the specific question referred to them, and attempting to estimate the reduction in cost obtainable by the use of novel materials or methods of construction, the committee found it necessary to consider what is the standard cost of school buildings according to the best existing practice. They, therefore, had to consider not only the actual present cost of school buildings, but also the causes to which that cost is attributable, and the means by which it might be reduced. In this connection the committee discussed the "useful life" for which an architect should allow in designing school buildings. As the standards of ventilation, lighting, sanitation, etc., have risen very greatly in the last 25 years, and as the purposes which a good school serves now are very different from those in vogue a few years ago, it is obvious that comparatively modern buildings have become old-fashioned, and those which were erected not long ago, and which are still structurally sound, have to be extensively altered or re-modelled in order to adapt them to the requirements of an up-to-date school. In designing school buildings, therefore, the architect cannot afford to overlook the possibility of their being re-modelled, or even abandoned, at some future date, and he should plan his buildings on the simplest possible lines, so as to facilitate alteration of the internal arrangements. He should recognise that the degree of durability and immunity from repairs, at which he may legitimately aim, is limited ; and that it is not good practice, either from an educational or from an economical point of view, to make school buildings as solid or durable as warehouses or churches. Moreover, as the population is of a shifting character, and it is uncertain whether any school or so large a school will be required in the locality after a limited period, something between a permanent and a temporary building is wanted.

The committee dealt at length with the circumstances affecting the cost of elementary school buildings. In the course of their remarks on this point, they commented favourably on the fact that the liking for florid and pretentious elevations is less prevalent, and that the general improvement of the public taste is reflected in a greater appreciation of simple, dignified, and appropriate exteriors on which decorative trimmings are conspicuous by their absence.

The evidence laid before the committee indicated that the most economical buildings had been provided by architects who have made a special study of school planning. It was also their opinion that by the employment of a local architectural staff substantial economy was effected. They had received evidence that in certain cases the specifications for school buildings have contained directions for the use of materials which had to be brought from a distance when equally satisfactory materials could be obtained at a cheaper rate in the immediate neighbourhood ; and in this connection we would point to the distinct usefulness of using concrete in districts where bricks cannot be obtained cheaply, and where stone is also scarce. In all such circumstances aggregates can be obtained for making concrete, and the cartage of the cement necessary would be a very small item of expense.

In concluding the remarks on the circumstances affecting the cost of school buildings, special emphasis was laid on the material saving which could be effected by attention to small savings on numerous items.

In dealing with the possibility of saving on certain details, the following extracts from the report may be of interest :

> ***Foundations.***—There is a considerable amount of evidence as to the value of reinforced concrete for the purposes of foundations in unstable soils. It has frequently been used in connection with school buildings, and was referred to particularly by Mr. Hutchings and Mr. Jacques—the latter had in one case saved about 80 per cent. of the cost of foundations by adopting a raft of reinforced concrete instead of carrying piers down to the solid ballast. The conditions in this instance were rather exceptional, but a material saving may be expected from the use of this system wherever the soil is at all treacherous, and Mr. Twelvetrees contended that even on fairly good ground a saving on the amount of material required for bases and footings might be effected by reinforcement.
>
> Mr. Slater, in the paper to which reference is made below, points out that, owing to the almost universal use of cement concrete, brick footings are now

practically superfluous, and greater strength at a less cost may be secured by making the footings of walls entirely of cement concrete. He estimates the average saving effected on this item at about 25 per cent.

Floors.—For the purposes of ground flooring Mr. Gilmour Wilson considered that boards laid on concrete would prove quite as satisfactory as, and cheaper than, wood blocks. The same point was taken by Colonel Drummond, and is developed in an article on "Structural Economy," by Mr. E. A. Slater, which has been brought to our notice. Mr. Lingen Barker recommended jointless floorings, such as cork adamant, as more economical in the long run than boards, on account of their greater durability, but he had not had actual experience of their ability to stand the wear of a public elementary school.

In upper floor construction the utility of reinforced concrete as an economical method has been widely recognised, and it seems clear that in most instances it effects a saving in cost over steel joists.

Roofs.—It was suggested to us by a few witnesses that some saving might be effected by the use of asbestos slating instead of ordinary slates or tiles : the economy would arise, not from the cheapness of the covering material, but from its greater lightness, which would permit of a considerable reduction in the scantling of the roof. This point was specially pressed upon us by Mr. Lingen Barker, who estimated that a roof of asbestos slates would cost, including the timber work, about 15s. a square less than a slated roof, the price of which he took at 40s. a square. We have examined roofs of this construction at Harrow Sanatorium and Borstal prison, and they seem to be satisfactory.

In some cases a flat roof of reinforced concrete covered with asphalte might be used, and would prove economical. For town schools this would have the additional advantage of supplying a roof playground, and would be fireproof.

NOVEL MATERIALS AND METHODS.

In the course of the inquiry into novel materials and methods, the following systems of construction were dealt with :

(i) *Steel Frame Buildings :*
   (*a*) with thin solid curtain walls of concrete ;
   (*b*) with hollow curtain walls of concrete slabs ;
   (*c*) with curtain walls of brick, hollow or solid ;
   (*d*) with curtain walls of patent materials ;
   (*e*) with hollow curtain walls of expanded metal faced with cement and plaster.
(ii) *Reinforced Brickwork.*
(iii) *"Ferro"-Concrete Buildings.*
(iv) *Brick Buildings with solid 9-in. walls.*
(v) *Brick Buildings with thin hollow walls.*
(vi) *Timber Frame Buildings with slab casing.*
(vii) *Wooden Buildings.*

(i)—(*a*) Steel Frame Buildings with Thin Solid Curtain Walls of Concrete.

In the course of this inquiry particulars of a building, erected for the Poor Law School at Anerley, were submitted by Mr. Cecil Sharp, A.R.I.B.A. A description of this building, with plans, appeared in our issue of November, 1909. The plans and particulars aroused interest among certain local education authorities, and the Liverpool Education Authority proposed to try a somewhat similar type of building at Liverpool. The total finished thickness of the concrete slabs at Liverpool would be 4¼ in. ; the slabs to be rough-cast outside, and plastered on the inner surface.

Mr. T. Ernest Hawkins gave particulars of the buildings at the Franco-British Exhibition, which are erected on this principle of steel frames and concrete slabs, upon which is placed the external cement and internal plaster treatment. Mr. Hawkins said :

> He had constructed schools, permanent and temporary, in all parts of the country, but was particularly a specialist with regard to the construction of temporary schools of wood and iron, and had been advocating for several years the utility of semi-permanent schools constructed of reinforced concrete slabs. He quoted the buildings erected by his firm at the Franco-British Exhibition. These were not put up as permanent structures, since the Exhibition was only expected to stand for three years ; but the principle could easily be adapted to give a much longer life. The majority of the buildings were of one storey, but there were some of two or three storeys. The whole of the weight was carried on steel framework, with curtain walls of 3-in. concrete slabs. An intermediate reinforcement of horizontal bars had to be used where the wall ran over a long span. The walls were plastered outside with lime plaster ; for a permanent building he would use cement rough-cast. Reinforced concrete slab buildings of this kind were most suitable for districts where it was impossible to gauge the possible requirements of the locality a few years ahead, and where more expensive buildings, if supplied, were often in a few years' time quite unsuitable for the altered conditions of the district.
>
> He considered that a satisfactory school building could be constructed on this principle with 3-in. walls, or 4-in. finished, for a single storey. Walls of this description were just as rigid, just as warm, and almost as lasting as a brick structure. This kind of structure would have been adopted by several local authorities if loans could be obtained on the same conditions as for brick structures. He had built temporary schools on this principle at Rotherham and Oldham.
>
> As to the life of these buildings, there was no reason to think that it was not equal to that of a brick building ; he would be prepared to guarantee them for 40 years. Their great recommendation was their extreme cheapness ; the cost worked out to under £4 per head. Such buildings were accepted by insurance offices as an even safer risk than brick buildings, and, their durability being equal, there was no reason why loans should not be granted for them on the same terms as for brick.
>
> The relative cost, for walls of school buildings, of reinforced concrete slabs and of brickwork, as ascertained from comparison with schools erected for the Middlesex and Surrey Education Committees, is as follows :—
>
> Concrete slab walling, finished (including plastering), with reinforced steel bars, 6s. 6d. per yd. super.
>
> Fourteen-in. brickwork (including facing and inside plastering), 13s. per yd. super.
>
> There is a further saving of 5 per cent. in the foundations of the former, which, distributed over the whole of the brickwork, would represent a total saving of 10 per cent. on the total brickwork cost. The walls in concrete slab being 4 in. thick, instead of 14 in., an increase of 5 per cent. is obtained in the cubical contents of the buildings.
>
> After examining the cost of various permanent schools erected in brickwork, he found that a total saving of approximately 22 per cent. on the gross total cost of the buildings would have been effected by using reinforced concrete slab walls ; while for semi-permanent works the saving could be made at least 33 per cent.

(i)—(*b*) *Steel Frame Buildings with Hollow Curtain Walls of Concrete Slabs.*

Mr. Cecil Sharp, who was examined in this connection, stated that in his opinion it would be an improvement to substitute hollow walls in concrete slabs for the solid wall. He drew attention to the necessity of having thoroughly seasoned concrete blocks ; blocks six months' old, he said, had reached their final state, and would not develop flaws or show movement.

The desirability of making concrete walls hollow was pointed out by Mr. H. D. Searles-Wood, F.R.I.B.A., who said that this was necessary to obviate the condensation which took place on the interior of the walls owing to the non-absorbent character of the concrete.

(i)—(*c*) *Steel Frame Buildings with Curtain Walls of Brick.*

The report mentions that this method, like the last, seemed to offer points worthy of consideration and to be likely to prove of service in some localities. Whether hollow brick or concrete filling in connection with steel framework would prove cheaper would be largely determined by the circumstances of the district in which the building was to be erected.

(i)—(*d*) *Steel Frame Buildings with Curtain Walls of Patent Materials.*

Various forms of patented blocks are used for forming the curtain walls of a steel or wooden framed structure, and several of these were examined. The one known as "Frazzi" is made up into hollow blocks, measuring about 2 ft. by 1, and 3 in. thick, strengthened internally by ribs. It is necessary to cement the outside as the blocks are not waterproof. It is claimed that these blocks when cemented together have sufficient strength and rigidity, in the case of small buildings, to stand and carry the weight of the roof.

(i)—(*e*) *Steel Frame Buildings with a Hollow Curtain Wall of Expanded Metal faced with Cement and Plaster.*

The committee gave particulars of a proposal which has been submitted to the Board of Education for the erection of a school at Nacton, in East Suffolk, on a method which has been extensively employed for cottages on Captain Pretyman's estate. A steel framework is constructed, strengthened by cross-wiring, and this frame is filled in with expanded metal lathing on both sides; the outer side is faced with a layer of cement and rough-cast 1½ in. thick, and the interior with ¾ in. of plaster, a cavity 6½ in. wide being left between the two sides; the lower part of the wall is built in brick up to plinth level, or, in the case of a school, to the under side of the window sills. Cottages designed on this system have been visited, and the result appears to be satisfactory, and there is no reason to suppose that it would be unsuitable for school purposes. In this particular district the high cost of brick building enables this form of construction to be used at 25 to 30 per cent. less cost than brick.

The report went on to say that in regard to steel frame construction generally, whatever form of filling may be adopted, attention has already been drawn to the fact that considerable economy would be effected in the space occupied by a school building, owing to the diminished thickness of the walls: Mr. W. E. Riley, F.R.I.B.A., estimated the saving in area at 8 per cent. A further advantage, which has also been mentioned above, and is common to all forms of steel framework, is the economy in foundations rendered possible by the lighter building; and on an insecure foundation a wall contained in a steel frame is certainly safer than a plain brick wall. On the other hand, all the forms of filling proposed require to be made weather-proof by a facing of cement rough-cast or a similar material.

(ii) *Reinforced Brickwork.*

A method of forming double walls, which it is claimed secures adequate constructional strength while permitting each wall to be built of 4½-in. brickwork, or even 3-in. by the use of brick on edge, was brought to the notice of the committee by Major H. S. R. E. Rogers, Surveyor to the Prisons Commission, who has used it extensively in prison work. At Borstal Prison, where it was used, the weight of the roof is carried on reinforced concrete piers built up on the spot. The method upon which the walls are constructed is known as "Reinforced Brickwork," and consists of the use of galvanised wire netting, strengthened by longitudinal wires and made of a suitable width to be entirely buried in the thickness of the wall, placed in every third or fourth course of the brickwork. This is said to increase the strength of the wall to a very marked degree, and to offer great possibility of economy in dealing with difficult sites and insecure foundations.

As regards cost, it is stated that a wall, built of brick on edge and reinforced every other course, in 2 to 1 cement mortar, will, in normal cases, cost about 2*s.* 7½*d.*

per yard super.; this will be reduced to 2*s*. 3½*d*. if the reinforcement is put in every third course. A 4½-in. wall will cost 3*s*. 11*d*. and 3*s*. 5*d*. respectively per yd. super.

A modified form of hollow brick wall is now being tried by Mr. Fisher for the Berkshire Local Education Authority; in this the wall is formed by two 3-in. thicknesses of brick on edge, reinforced with steel wire mesh, and a 3-in. space between; the weight is taken on piers of solid 9-in. brickwork reinforced, so giving a 9-in. wall throughout, which is hollow between the piers.

The evidence seemed to be in favour of the conclusion that hollow walls of reinforced brickwork might prove suitable and satisfactory for school purposes and under some conditions might also be economical.

(iii)—"*Ferro*"-*Concrete Buildings.*

The committee reported that they had received a considerable amount of evidence as to the possibility and advantages of employing for school buildings the various types of reinforced concrete construction. In the course of their examination on this point the following evidence was given by Mr. W. Noble Twelvetrees:

> Mr. Twelvetrees pointed out that the material (*a*) lends itself to any style of architecture; (*b*) can be employed for the construction of every detail from foundations to roofs, the building being monolithic throughout; (*c*) can be used for the construction of a skeleton frame supporting and transmitting all loads to the ground; the panels of the walls and roofs can be filled in with ordinary materials, which, having no load to carry in the walls, may be much thinner than the usual type; (*d*) makes a building of exceptional strength and capable of acting as a single unit, and thus unaffected by any subsidence or local weakness under the foundations; (*e*) is one of the best fire-resisting materials known; (*f*) is suitable on hygienic grounds, being impenetrable by vermin, harbouring no germs, and checking exhalations and moisture; being non-porous and non-conductive, it conduces to equable temperature; (*g*) concrete increases in strength with age and is free from decay and corrosion, thus needing no maintenance or repairs beyond cleansing and painting for decorative purposes. On the last point, he drew attention to the fact that the durability of steel and concrete used separately had never been questioned by architects, and, therefore, their durability when used in combination ought to be accepted.
>
> On buildings of two storeys there would be a saving of about 5 per cent. all round on first cost and on higher buildings an additional 5 per cent. per storey up to a maximum of 15 or 20 per cent. In any case there would be a saving in maintenance, as no repair would be required. Witness would prefer to make a reinforced concrete skeleton, like a steel skeleton, and fill in the walls with concrete hollow blocks, bricks, or hollow bricks. There would be a saving of 10 to 20 per cent. over a steel skeleton, and the same over ordinary brick construction.
>
> Taking the items of construction separately, witness said that in foundations reinforced concrete offered great economies for unstable soil, while even in fairly solid soil reinforced concrete column bases required far less material than ordinary footings extending beneath the whole length of the walls, and thus effected a saving. He quoted a case of a building at Newcastle-on-Tyne where a reinforced concrete raft had been put under the building, and had resulted in a saving of 50 per cent. on the original design of a concrete foundation of piers going down to the solid. Similarly, at the General Post Office column foundations in reinforced concrete had been used and saved about 50 per cent. on ordinary concrete blocks.
>
> In regard to columns, he estimated that reinforced concrete would give a saving of about 25 per cent. over steel columns to carry the same loads and could be used to carry a strain where a brick column would be of prohibitive cost, as the safe compressive strength of concrete properly reinforced averages ten times that of brick masonry. The concrete column would also be better than protected steel for resisting fire. He agreed, however, that from the point of view of the Board of Education steel columns from a good maker would require less super-

vision during erection than reinforced concrete columns, unless the latter were executed by thoroughly reliable and experienced contractors.

Witness thought that the only economy in the construction of walls arising from the use of reinforced concrete would be due to the possibility of replacing thick masonry by thin curtain walls, as these would not have to carry any load. Interior walls could be put up very cheaply of special slabs or by plastering cement mortar on expanded metal or other types of lathing.

As regards floors, he admitted that reinforced concrete was dearer than timber, but considered it would usually come out cheaper than steel joists with plain concrete or tile panels ; he had particulars of three cases where the saving was 11½, 12½, and 15 per cent. respectively. The reinforced concrete was also less susceptible to heat, and so safer in case of fire, than steel joists.

For the purpose of staircases there was no saving in the use of reinforced concrete, but the material was better. When exposed to fire, it did not splinter and crack like stone, it did not burn like wood, and it did not buckle like steel.

He thought that for flat roofs there was an economy in the use of reinforced concrete ; there would be no saving in a sloping roof, but the material might be employed with advantage, as it would make a roof impervious to moisture and immune from injury by fire.

(iv) *Brick Buildings with solid 9-inch Walls.*

The report states that the Board of Education have several times been asked by local authorities to sanction plans showing solid brick walls only 9 in. thick, and that there is practically unanimous agreement among the witnesses that a plain 9-in. brick wall would be satisfactory "if covered with rough-cast or cement or other impervious surface," especially in the case of small single-storey country schools. The committee thought it doubtful whether it would, at all events if built in mortar, give sufficient constructional strength, in view of the long walls without cross walls that a school requires. On the whole, while it did not appear to them that any great saving would be effected by the adoption of 9-in. in place of 14-in. brick walls, they were of opinion that a 9-in. wall, if properly supported and suitably treated on the outside with rough-cast, cement, stucco or other material which will ensure dryness and contribute to warmth, might be permitted for school buildings.

(v) *Buildings with Thin Hollow Brick Walls.*

Most of the witnesses regarded such walls as better than 9-in. solid brick walls for retaining warmth and resisting damp, but inferior in constructional strength and objectionable on account of their tendency to transmit sound.

(vi) *Timber-Framed Buildings with Slab Casing.*

In this connection the committee had visited a sanatorium, at Harrow, erected on this method. The outer walls are formed of timber framing 4 in. thick, cased on the outside with "Fram" slabs 2 in. thick, and on the inside with similar slabs 1 in. thick, the outside finished with cement rough-cast. This appeared to make a sound and comfortable building.

(vii) *Wooden Buildings.*

Generally the committee found that wooden buildings were more comfortable and satisfactory than buildings of corrugated iron lined with wood, but they would require a larger expenditure for maintenance. The chief objection to wooden buildings is the risk of fire.

BY-LAWS AND BUILDING ACTS.

It was the unanimous opinion of the witnesses examined that school buildings should be placed on the same footing as buildings erected under the approval of a Secretary of State and other buildings exempted from the operation of local by-laws and Building Acts, and that legislation should be promoted for this purpose. They regard it as quite sufficient guarantee for the soundness of the structural design of a school that the plans should have been passed by the Local Education Authority and the Board of Education.

GENERAL CONCLUSIONS.

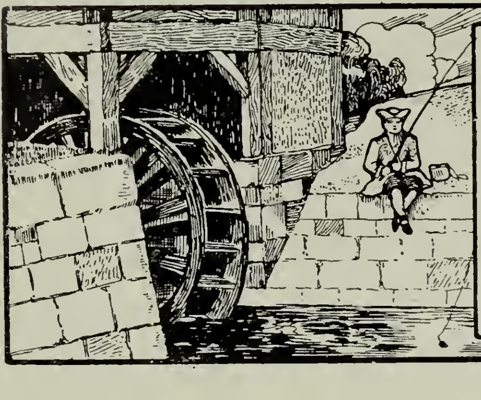
The following are the conclusions arrived at by the committee :

We have been much impressed in the course of our inquiry with the great economies which can be secured by good designing, careful attention to details of construction and finish, and by keeping in view the probabilities which affect the " useful life " of school buildings. Taking the country as a whole, it is probable that for some time to come there will be as much saving effected in the erection of school buildings by skilful and businesslike employment of methods and materials in ordinary use, as by adoption of novel methods and materials . . . We have already expressed our admiration of the work which is being done in certain areas by school architects working under enlightened and business-like local authorities. Whatever materials or methods of construction they may adopt in the future, we look with some confidence to their example to effect a substantial reduction in the average cost of school buildings coupled with an increase in their efficiency.

We have been embarrassed in our inquiry by the small number of buildings erected on novel lines which are at all comparable with school buildings, or which would enable us to judge how far the methods and materials employed are really suitable for school purposes. We find it difficult therefore to speak with much confidence on this point, and our recommendations can amount to little more than an expression of opinion in favour of experiment. Most of the witnesses who have assisted us were themselves commendably modest in their claims for the systems they advocated, and very candid in discussing objections to them. The scarcity of experimental school buildings is attributable partly to the natural preference by architects for materials and methods with which they are thoroughly familiar, and which require comparatively little supervision of the work in process of execution. It is also attributable to a great extent to the fact that the Building Regulations of the Board of Education do not contemplate, and do not encourage, experiment in novel materials or methods, and that in areas where the other conditions are most favourable to experiment the building by-laws do not admit of it.

We have accordingly found ourselves obliged, in dealing with our reference. to consider ourselves as mainly concerned with the questions (*a*) do recent developments in building practice show a fair promise of reducing the cost of school buildings if existing obstacles to experiments in construction are removed ; and, if that question is answered in the affirmative, (*b*) what steps can, and should, be taken to facilitate such experiments ?

We do not regard ourselves as competent to pronounce authoritatively, as a technical commission might pronounce, for or against particular devices ; but, after making all allowance for the great difference in cost, as well as in efficiency, between good and bad school planning and good and bad construction with ordinary materials, and for the possible saving by means of greater care and skill in their use, we are satisfied that several of the suggestions made to us are distinctly promising and offer a fair prospect of further saving. We therefore feel justified in answering the first question in the affirmative. As regards the second question, we have no hesitation in recommending that the existing obstacles to experiment should be removed, and that the Board of Education and the Local Government Board should be placed in a position to facilitate the execution of such proposals for the use of new materials or methods of construction, submitted to them by or through local education authorities, as commend themselves after due consideration. While we do not contemplate or anticipate anything like a sudden revolution in school building, we do not, on the other hand, consider that either the local education authorities or the Government departments concerned are justified in maintaining an unduly conservative attitude.



CONCRETE TANKS AND HOW TO MAKE THEM.

The following description of how to make concrete tanks should be found of great assistance to those desirous of carrying out concrete work on the farm. It is taken from a pamphlet issued by the Association of American Portland Cement Manufacturers.—ED.

Probably in no other way has concrete been more advantageously used than in the building of tanks. If one will stop to consider the use to which tanks are put, their diversity of location, and the great variety of shapes into which convenience moulds them, it will be understood why concrete is an ideal material for their construction.

If a tank is to be built to withstand a large head of water, or under peculiar and difficult conditions, the services of an engineer should be employed, but for the ordinary tanks holding from one barrel of water to 20,000 gal., a man with some ingenuity and some knowledge of how to mix and place concrete can easily build one. This fact is of particular advantage to the farmer. Winter is the dull time on the farm, and tanks for the storage of water either in the house or in the barn can be built at this time with the help of farm labour.

ADVANTAGES OF CONCRETE TANKS.

Only a tank of concrete can be built to occupy the entire space, as this is the only kind of tank which needs no repairs. Tanks built of any other material require, in time, repairs from the outside, and space must be left that these repairs can be made. Wooden and steel tanks must be painted or caulked from both the inside and outside to prevent permanent leakage, or to keep them from so deteriorating as to render them useless. A concrete tank does not deteriorate in any way. Both wooden and iron tanks go to pieces rapidly when alternately wet and dry, the wood from rotting and the iron from rusting, particularly where they are subjected to extreme changes of temperature and a lack of circulation of air. Vermin also collect in and around them, and wooden tanks are often rendered useless by the vermin eating holes through the tank. Tanks of wood dry out in hot weather, and as they can never be built in one piece, the joints are sure to open if the tank is left empty in summer.

The importance of a sanitary condition is becoming more and more recognised for both men and animals, as new scientific investigations go to prove that all diseases arise from lack of proper sanitary measures. In consequence, the ability to easily clean a tank is considered of prime importance. Nothing is easier than to drain a concrete tank and scrub out the inside whenever desired. Not only that, but practically all the impurities which can accumulate are brought in by the water itself, and the surface of the concrete does not absorb them as does a porous material such as wood.

In order to perfectly hold the water or other content, a tank must act as one piece. A concrete tank is, owing to the way it is built, a one-piece tank, without joints, and therefore cannot crack or separate.

RECTANGULAR TANKS.

Laying Out the Ground.—After the size has been decided upon, select a site near the water supply if possible, and mark off the ground. In selecting the size, remember that 7½ gal. make 1 cu. ft., and that a barrel holds from 49 gal. to 54 gal.

Put four nails in the ground in the shape of a rectangle, to mark the outside line of the tank walls, and stretch strings from nail to nail. Excavate inside the space thus marked to a depth of 6 in. or 8 in. If the soil is good stiff material, the bottom of the tank may be placed directly on this ground. If the ground is soft, dig a trench just inside the strings 1 ft. deep and 1 ft. wide to secure additional foundations.

The ground under the proposed tank should be thoroughly tamped with as heavy a tamper as one or two men can handle. A block of wood, square or round, 12 in. or 14 in. across. with handles for lifting, makes an excellent tamper.

Building the Inside Forms.—For purposes of illustration we will describe how to build a tank 4 ft. by 4 ft. by 6 ft. high. This tank will hold 720 gal., or 15 barrels.

Cut eight posts of 2-in. by 4-in. stuff 7 ft. long. Taper the posts slightly for about 6 in. at the bottom. Then cut enough 1-in. surfaced boards to make two sides of the inside forms, making each board 3 ft. 10 in. long.

Make two marks on each post, the first 4 in. and the second 6 ft. 4 in. from the tapered end. These marks give you the bottom and top lines of the forms. Lay three posts on the ground, edge up, and nail on the first board, with its edge on the mark made 4 in. from the end of the post. Two posts should come flush with the ends of the 3-ft. 10-in. board, and the other near the middle. Nail on enough boards to fill the space between the two marks. This makes one side of the inside forms, and two such sides should be constructed.*

Cut enough 1-in. surfaced boards 4 ft. long to complete the other two sides. Cut four more pieces of 1-in. board 3 ft. 10 in. long to be used for bracing the two sides already framed. Place them opposite each other, and 6½ in. inside the string already stretched, with the posts on the inside. Hold the sides upright, and nail on two braces to the middle posts, using two of the last 3-ft. 10-in. boards which were cut for braces. In nailing these boards, their ends should come against the 1-in. surfaced boards of the side forms. This will keep these forms the correct distance apart. Nail the 4-ft. boards to the end posts of the sides already in place, making the ends come flush with the outside of the forms erected. Place the middle posts inside these boards, and nail on the braces. Then nail the boards to the post from the outside. Place bricks or stones under each post, raising them about 2 in. from the ground, taking care that the form is level and that the sides are plumb.

Amount of Reinforcement in Bottom of Tank.—The thickness of bottom will be made in all cases 6 in.; for tanks of this depth reinforcement must be placed 2 in. from the bottom of the slab, and this reinforcement must run each way.

Placing Reinforcing.—By referring to Table I., we find it necessary to use in the bottom one ½-in. round steel rod every 14 in., or five rods in each direction across the tank. These should be cut in lengths of 5 ft. each. Lay them on the ground spaced properly, the rods in one direction resting on the rods in the other. Then cut the rods for the vertical reinforcement of the wall.

TABLE I.

Depth of Tank.	Spacing of ⅜-in. Round Rods.	Spacing of ½-in. Round Rods.	Spacing of ¾-in. Round Rods.
3 ft.	10 in.	—	—
4 ,,	8 ,,	16 in.	—
5 ,,	7½ ,,	15 ,,	—
6 ,,	7 ,,	14 ,,	—
7 ,,	6½ ,,	13 ,,	—
8 ,,	6 ,,	12 ,,	24 in.
9 ,,	5 ,,	10 ,,	20 ,,
10 ,,	4 ,,	8 ,,	16 ,,

By referring to Table II., we find that for a tank 6 ft. deep we require ½-in. round rods spaced 5 in. apart. Fifty-two of these will be required. These rods should be cut 7 ft. long. Make a hook at each end of these bars. This can be done by placing the end of the bar between two heavy spikes nailed in a block of wood and bending by moving the other end of the bar. The length of these bars after they have been bent should be about 6 ft. 4 in. Rods should also be bent for the horizontal reinforcing. From Table II. we see that for this sized tank ½-in. round bars spaced 10 in. apart are required. Seven of these will be needed on a side.

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* An illustration of a form suitable for making a rectangular tank appears on page 197 of our previous issue.—Ed.

TABLE II.

Showing Size and Spacing of Rods in Wall.

Depth of Tank.	Thickness of Wall.	Spacing of ⅜-in. Round Rods.		Spacing of ½-in. Round Rods.		Spacing of ¾-in. Round Rods.		Spacing of 1-in. Round Rods.	
		Vertical.	Horizontal.	Vertical.	Horizontal.	Vertical.	Horizontal.	Vertical.	Horizontal.
Ft.	In.	In.	In.	In.	In.	In.	In.	In.	In.
3	5	5	10	10	20	—	—	—	—
4	5	4	8	8	16	16	32	—	—
5	5½	3	6	6	12	12	24	—	—
6	6½	2½	5	5	10	10	20	18	36
7	8	—	—	3	6	7	14	15	30
8	9½	—	—	2½	5	5	10	11	22
9	10½	—	—	—	—	5	10	10	20
10	12	—	—	—	—	4	8	8	16

The ½-in. rods with hooks at each end should now be placed in position. This is done by hooking the lower end of all the bars on one side under the rods in the bottom reinforcing, coming about 2 in. outside the line of the form which has been erected, as shown in *Fig.* 1, bars marked A and B. These bars should be placed, as we have previously stated, 5 in. apart. After hooking the lower end under one of the rods of the bottom reinforcement, the top end should be temporarily attached to the side of the form, by tying a wire around the hook in the top of the bar, and fastening this wire to a nail in the top edge of the form in such a way that it can be easily removed. After having placed these vertical ½-in. round rods in the correct positions, the next step is to place the horizontal reinforcement for the walls. This we have previously seen consists of ½-in. round bars spaced 10 in. apart. Attach these horizontal bars every 10 in. to the vertical reinforcement just placed by means of wires twisted tight enough to keep the horizontals from slipping down. An important point in placing this horizontal reinforcement is to take care that the ends of the horizontal bars do not meet at a corner. These bars can usually be obtained in lengths up to 20 ft. The size of the tank will determine the best lengths to cut. Bars 19 ft. long will be most economical for this sized tank. The bars for horizontal side reinforcing should then be cut in half for convenience in handling, making each piece 9 ft. 6 in. long. Fourteen of these pieces will be required. Bend each piece at each end 2 ft. 7 in. from the end at right angles, making a shape 4 ft. 4 in. long in the centre with 2 ft. 7 in. turned up at each end. (See *Fig.* 2.) Wire these pieces to the vertical reinforcement already placed. The ends of these pieces will overlap on two of the sides about a foot. If it is not possible

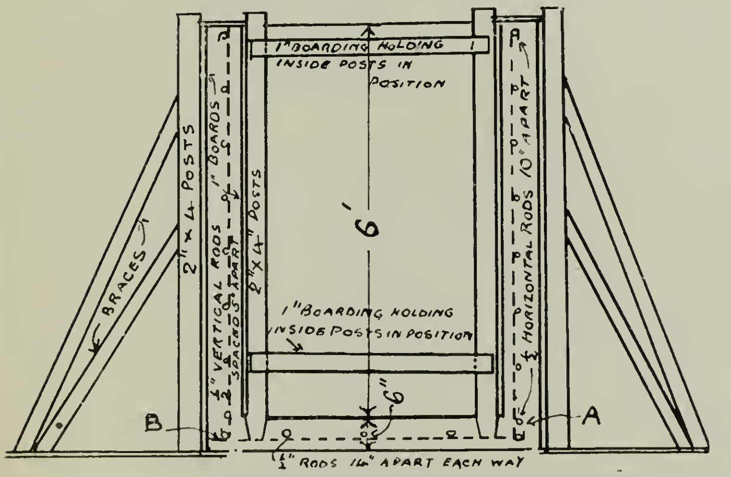

1" BOARDING HOLDING INSIDE POSTS IN POSITION
2" × 4" POSTS
1" BOARDS
BRACES
½" VERTICAL RODS SPACED 5" APART
2" × 4" POSTS
6'
1" BOARDING HOLDING INSIDE POSTS IN POSITION
6"
½" HORIZONTAL RODS 10" APART
B
A
½" RODS 14" APART EACH WAY

Fig. 1. Section through Centre of Form, showing Reinforcement in Place.

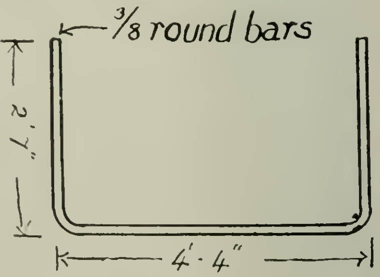


Fig. 2. Shape into which Bars are bent for Horizontal Reinforcement.

to obtain the bars in sufficient lengths to bend into the shape described, they should be bent into L shapes, and the ends be made to overlap about a foot as near the centre of each side as possible. Where these bars lap, they should be firmly wired together. The top horizontal bar should be placed immediately under the hook in the top of the verticals. This completes the reinforcement for the tank.

The outside forms should now be built. These consist of 3-in. by 4-in. posts 7 ft. long and of 1-in. surface boards. Lay two of the posts on the ground and nail 1-in. surface boards to them. For two of the sides these 1-in. boards should be cut 5 ft. 1 in. long, and enough of them should be used to cover the posts to a height of 6 ft. 6 in. The bottom of the first board should come exactly at the bottom of the posts, the ends of the boards being flush with the outside edge of the posts. For the other two sides the 1-in. boards should be cut 5 ft. 3 in. long and should be nailed to the posts in the same way, except that the ends of the boards should project beyond the edge of the posts 2 in. A third post should be slipped under the 1-in. boards after they have been nailed to the two end posts and half-way between them, and the boards nailed to this third piece. When this has been done, the four sides for the outside forms have been built. The two sides for which the 5-ft. 1-in. boards have been used should now be set in place, parallel with the inside form previously erected and 6½ in. outside of it. Care should be taken that the space of 6½ in., which we see from Table II. is the thickness of wall required for a tank 6 ft. deep, is left between the two forms. These sides which have just been placed should also be carefully adjusted so that the outer ends project beyond the previously erected form 6½ in. at each end. This position provides the required thickness of the wall on the other two sides.

Under the bottom of each post a 1-in. board 4 ft. long should be slipped. Cleats should now be nailed at the top of the inside and outside posts, to hold the top of the forms in position. Drive a stake into the ground at the outside end of the board which has been slipped under the posts of the outside form, and then nail inclined braces from this board up to the posts. Place in position the other two sides of the outside forms. The 1-in. boards for these sides were cut 5ft. 3in. long, and the ends should overlap the two sides of the outside form which are now standing 1 in. at each end. As the posts for these two sides were kept back from the ends 2 in., they can be readily nailed to the two sides which were first erected. The posts of these two sides should also rest on 1-in. planks, and should be braced by inclined bracing, and the top spaced correctly by nailing the cleats between the inside and outside posts. A tight joint should be secured at each corner and clay or loam should be packed outside the bottom of the outside form so that none of the concrete can escape. One at a time the wires by means of which the vertical reinforcement was temporarily attached to the inside form should be loosened. By means of wires attached to the top horizontal rod, and the cleats which hold the inside and outside forms the correct distance apart, the wall reinforcement can now be placed permanently in the correct position. This wall reinforcement should be 2 in. from the inside form, and the wire between the top horizontal bar and the cleats should be twisted tight until the reinforcement in the bottom of the tank, around which the bottom end of the vertical is hooked, is raised 2 in. from the ground. This bottom reinforcement will sag in the centre, and a brick or stone should be placed under it so that it is everywhere 2 in. above the ground. This allows a 2-in. layer of concrete to be placed beneath the bottom reinforcement.

Placing the Concrete.—The concrete should now be mixed in proportion of 1 part Portland cement, 2 of sand, and 4 of stone, with enough water to make a sloppy mixture. Then place it in the bottom of the tank by throwing it into the centre of the inside forms and spreading it evenly over the bottom, taking care that a layer 2 in. thick is secured under the bottom reinforcement. After the bottom, which is 6 in. thick, has been completed, concrete should be placed between the wall forms, taking care that the walls are built up evenly on all four sides. The placing of the concrete should proceed without intermission until the top of the wall is reached. Smooth off the top of the concrete with a trowel. After the concrete has been allowed to harden about twelve hours, the forms should be removed. All of the inside posts which were tapered should be pulled out of the bottom of the concrete and the holes in the concrete should be filled up with a mixture of 1 part Portland cement, 2 parts sand, and enough water to make a thick paste. If there are any rough places in the walls, they can be easily filled up with cement mortar—1 part Portland cement, 2 parts sand—and if a particularly smooth job is desired, the inside and outside can be painted with a thin mixture of this same proportion.

CIRCULAR CONCRETE TANKS.

It is sometimes desirable to build tanks round instead of square. The forms for such a tank can be built exactly in the same manner as for building silo forms. Table III. gives the amount of horizontal and vertical reinforcement necessary for a water-tank. This reinforcement should be placed in the centre of the wall. Concrete used for the purpose of constructing circular tanks should be mixed 1 part Portland cement, 2 parts sand, 4 parts stone or gravel. It should be mixed thoroughly and made fairly wet. It should be carefully spaded while being placed.

TABLE III.

(1) Depth.	(2) Diameter.	(3) Thickness of Concrete in Wall.	(4) Diameter of Horizontal Rods.	(5) Spacing Horizontal Rods at Bottom.	(6) Spacing Horizontal Rods at Top.	(7) Diameter Vertical Rods.	(8) Spacing Vertical Rods.
Ft.	Ft.	In.	In.	In.	In.	In.	In.
5	5	6	¼	8	18	¼	36
5	10	6	¼	6	12	¼	30
10	10	8	⅜	6	18	⅜	36
10	15	9	⅜	4	18	⅜	36
15	10	10	⅜	4	18	⅜	30
15	15	12	½	6	20	⅜	30

We will illustrate the method of using this table in building a tank 15 ft. deep and 10 ft. in diameter. From the table we see that the thickness of concrete in the walls of the tank is 10 in. ; that the size of reinforcement to be used is ⅜-in. rods—that is, round rods ⅜ in. in diameter ; for the first foot these rods should be spaced 4 in. apart, and the vertical rods should be placed 30 in. apart. The table calls for the spacing of the horizontal rods 18 in. apart at the top of the tank, and the intermediate horizontal rods will therefore be spaced distances varying from 18 in. to 4 in. ; thus in the second foot from the bottom the horizontal rods will be 5 in. apart ; in the third foot 6 in. apart, and so on to the fifteenth foot, where they will be 18 in. apart.

Methods of placing this reinforcement are the same as described for square tanks.

The tanks so far described are those coming above the ground. For cisterns, wells, or tanks below the ground practically the same procedure is followed, with the exception of the fact that, as a rule, outside forms are unnecessary. In placing a cistern, mark out the size desired on the ground by driving nails and stretching a string around them, and dig a hole to the desired depth inside the strings. The ground in which this hole is dug will usually be stiff enough to stand up without bracing, and if this is the case, should be used as the outside form. Inside forms can be made as described above and lowered into the hole. The concrete is then placed by dumping from the top. The thickness of the bottom, and of the walls, and the amount of reinforcing will be the same as those described above. If the ground is not stiff enough to stand up alone, and it is necessary to slope the sides, outside forms become necessary, and are built in the same way as described for tanks above the ground.

CONCRETE ROOFS FOR TANKS, CISTERNS OR WELLS.

All cisterns and many wells are provided with coverings, and these can be easily made of concrete. Their advantage is obvious from the standpoints of both cleanliness and permanence.

After the concrete for the side walls has been brought to the proper height, place a 5-in. board above it, and nail to the posts of the outside forms as shown in *Fig.* 3. In case no outside forms are used, this board can be held in position by driving stakes 1 in. from the outside face of the tank wall, and bracing.

Saw or cut off the posts of the inside forms 5 in. below the top of the concrete, and nail 2 in. by 4 in. joists to the top of these. Then place a 2-in. board or two 1-in. boards on the concrete in the bottom of the tank, and on this place a row of posts under each 2 in. by 4 in., to support them in the middle. If these posts are not cut the exact length, they can be raised into place by wedging between the board on the bottom and the lower end of the post. These posts can be of either 2 in. by 4 in. or 3 in. by 4 in. lumber. Toe nail the bottom of the posts, and fasten the top by nailing through the 2 in. by 4 in. from the upper side. Now cover the top of the tank inside the walls with 1-in. boards. There is no reason for using surfaced stuff, but the boards should fit tightly together. In case cracks are left between after placing, they can be filled by smearing a little clay in them.

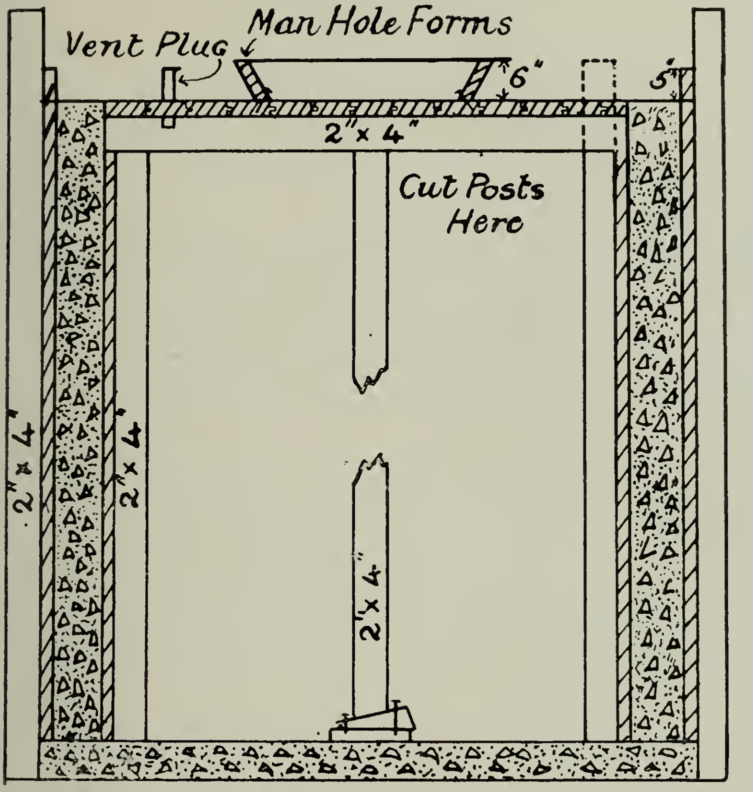


Fig. 3. Method of Forming Concrete Roofs for Tanks.

Next place a box with sloping sides, the large end being placed up, and fasten securely to the boards covering the tank. This is to provide for a manhole in the top of the tank. We suggest a hole 2 ft. square. The sides of the box should be 6 in. above these boards. You are now ready to place concrete. The thickness of the concrete should be 6 in. in the middle, sloping to 5 in. on the edges, and you have already a gauge for these thicknesses, in the heights of the side forms and of the box in the middle. Any openings besides the manhole should be provided for, by boring a hole of the desired size and in the desired location in the forms, and either driving a pipe into it or a plug of wood. These should extend more than 6 in. above the form. Place 2 in. of concrete over the entire form, then put a sheet of heavy chicken wire, coming to within 3 in. of all edges, and place the rest of the concrete, making it come 6 in. in the centre (to the top of the form for the manhole) and 5 in. at the edges (to the top of the form around the outside). The concrete should not be too wet, and should be tamped until water flushes to the surface. Finish the top by trowelling or with a rough float.

A mixture of 1 part Portland cement, 2 parts sand, and 4 parts broken stone or gravel should be used.

The manhole cover is now to be made. After the concrete in the tank roof has hardened for two or three days, remove the form around the manhole. As it is only necessary to make the manhole cover 3 in. thick, place a false bottom of boards in the hole, so that the top comes 3 in. below the concrete sides. Place the lifting rings in position by boring two holes in this false bottom, large enough to take the nut, allowing the washer to lie on top. If these just about fit, the stay bolt and ring needs no other support. Put cardboard, heavy building or tar paper against the edges of concrete already exposed, and fill the hole with concrete even with the roof already in place.

After 1½ in. of concrete have been placed, lay in a square of chicken wire, large enough to come within 1 in. of the edge. To do this cut two holes through it to allow the lifting rings to pass through. Then complete the concreting, bringing same to an elevation even with the top of the concrete already finished. Two lifting rings are provided, as the cover will weigh about 150 lb. The rings should be large enough to allow both hands to grasp one ring. After the concrete has set one week, the cover can be removed by means of the rings. In case it sticks, it can easily be prised up by a lever through the ring, using a block on the finished concrete top as a heel.

Space does not permit us to describe in detail the erecting of the great variety of various shaped tanks which have been used. One can readily see that a tank of any size and of any dimensions can be built in exactly the same way as those described, by simply varying the size of the forms.

THE NEW CENTRAL Y.M.C.A. BUILDING, LONDON.

One of the most important examples of reinforced concrete work is in the Y.M.C.A. building now in course of construction, and detailed particulars of the work, together with numerous drawings showing the principal features of interest, are contained in the article below, which was prepared for us by Mr. Albert Lakeman, Hon. Medallist Construction.—Ed.

The adoption of reinforced concrete as the chief constructional factor in large buildings is becoming so universal that the mere fact of its use in any particular building almost ceases to awaken interest to any great extent ; but special features, such as occur in the new Y.M.C.A. building, are always worthy of study on the part of those interested in the design and execution of this important material. The whole of the weight-carrying members are executed in reinforced concrete, which carries out those functions latterly assigned to the beams and stancheons in a steel-framed structure, while the external walls, faced with brick and stone, are treated from the architectural point of view without materially assisting in carrying the weights of the floors and roofs.

The planning and design of the building, the architect for which is Mr. Rowland Plumbe, F.R.I.B.A., was materially helped by the fact that the site is an island one, which rendered it possible to obtain access on all four sides. The area of the site is about 33,000 sq. ft., and it has a frontage of 218 ft. to Great Russell Street, 106 ft. 9 in. to Tottenham Court Road, 225 ft. to Bedford Avenue, and 148 ft. 10 in. to Caroline Street. There are six floors above the street level and deep basement floor, while a tower rises at the corner of Tottenham Court Road and Great Russell Street to a height of 156 ft. above the basement floor level. The principal entrance is situated in Great Russell Street, and this gives access to the main entrance hall, which is a circular chamber 43 ft. in diameter, containing the grand circular staircase, some details of which are given in this article. From the entrance hall access is afforded to the Club Restaurant, while the public restaurant is situated beyond this apartment with its own separate entrance in Bedford Avenue. The Tottenham Court Road frontage on the ground floor is taken up by five shops, which extend into the building for a depth of 70 ft. The elevation to Caroline Street provides the entrance to the large and small halls, which are situated on this side of the ground floor, the former being a fine apartment, 70 ft. by 48 ft., with a gallery on three sides, and having accommodation for 850 people, while the latter is 52 ft. by 36 ft., with accommodation for 300 people. The basement accommodation provides a fine gymnasium and swimming bath, and some interesting construction occurs in connection with these.

The swimming bath, shown in *Figs.* 3 & 9, is constructed entirely in reinforced concrete, the size being 66 ft. by 21 ft., with a maximum depth of 7 ft. and a minimum depth of 4 ft. 6 in. The walls employed were very thin, being only 4 in. at the top, with an increase to 5 in. at the bottom, where a splay is formed on the outside to increase the bearing and form a footing. A splay is also formed at the top of the walls to allow the reinforcement to be continued up into the floor around the bath, and provide for a 6-in. offset on the inside face of the wall for fixing the scum trough. The height of the walls was kept uniform at 7 ft., and the difference in level required in the bath gained by sloping the slab forming the bottom between the longitudinal walls. The walls were stiffened by the introduction of vertical counterforts 4 in. wide and 6 in. projection at 6 ft. 6 in. centres, and buttresses were also constructed at the corners on the diagonal lines. The plan of the bath and details of the method of construction are given in *Fig.* 3, where it will be seen that the floor, 5 in. thick, is reinforced with light bars in the upper and lower surfaces, some of which are continued up into the walls, and the counterforts are reinforced with vertical bars connected by

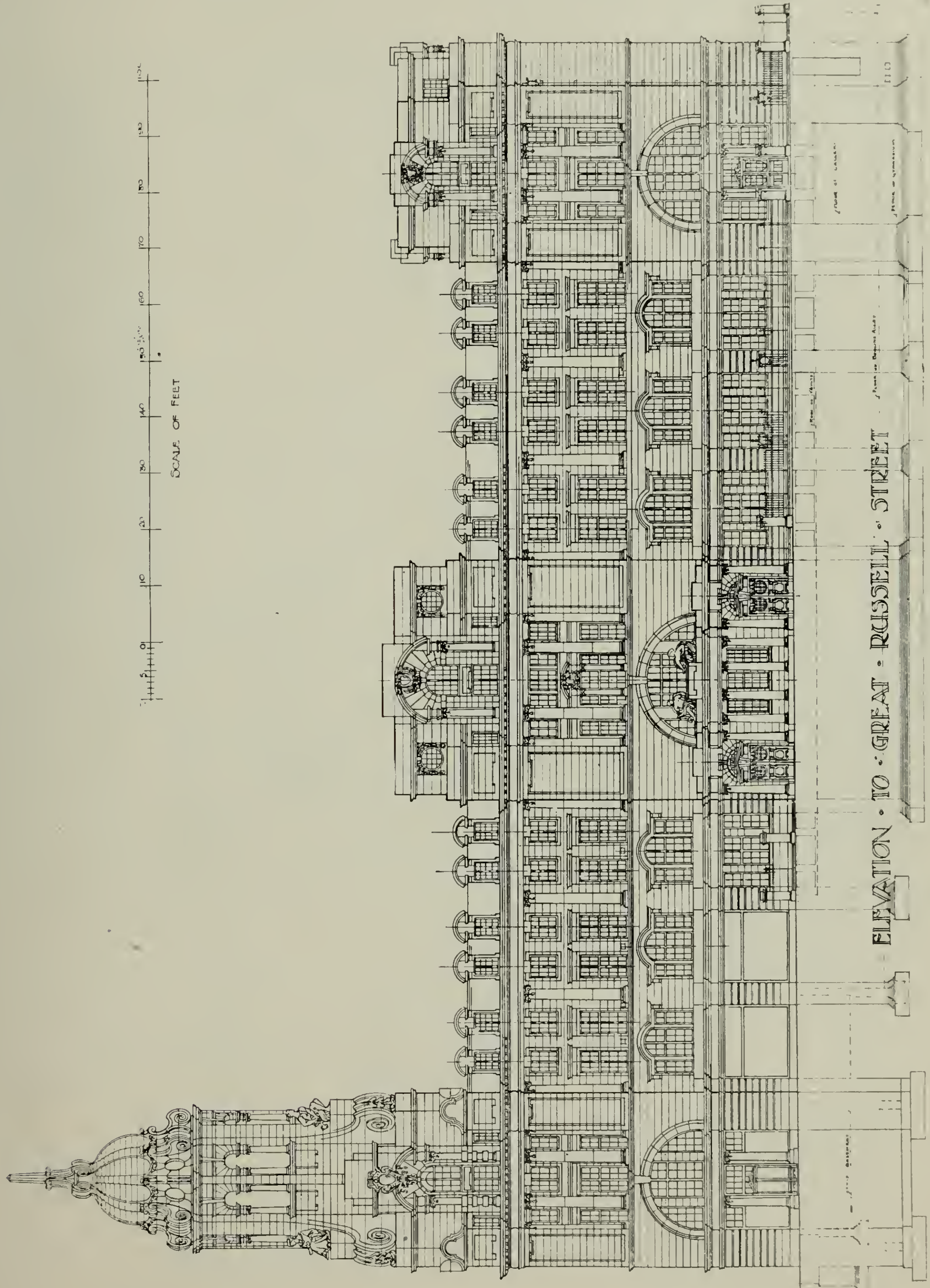


Fig. 1. Elevation.

The New Central Y.M.C.A. Building.

stirrups. The walls have vertical and horizontal bars in both surfaces, with stirrups

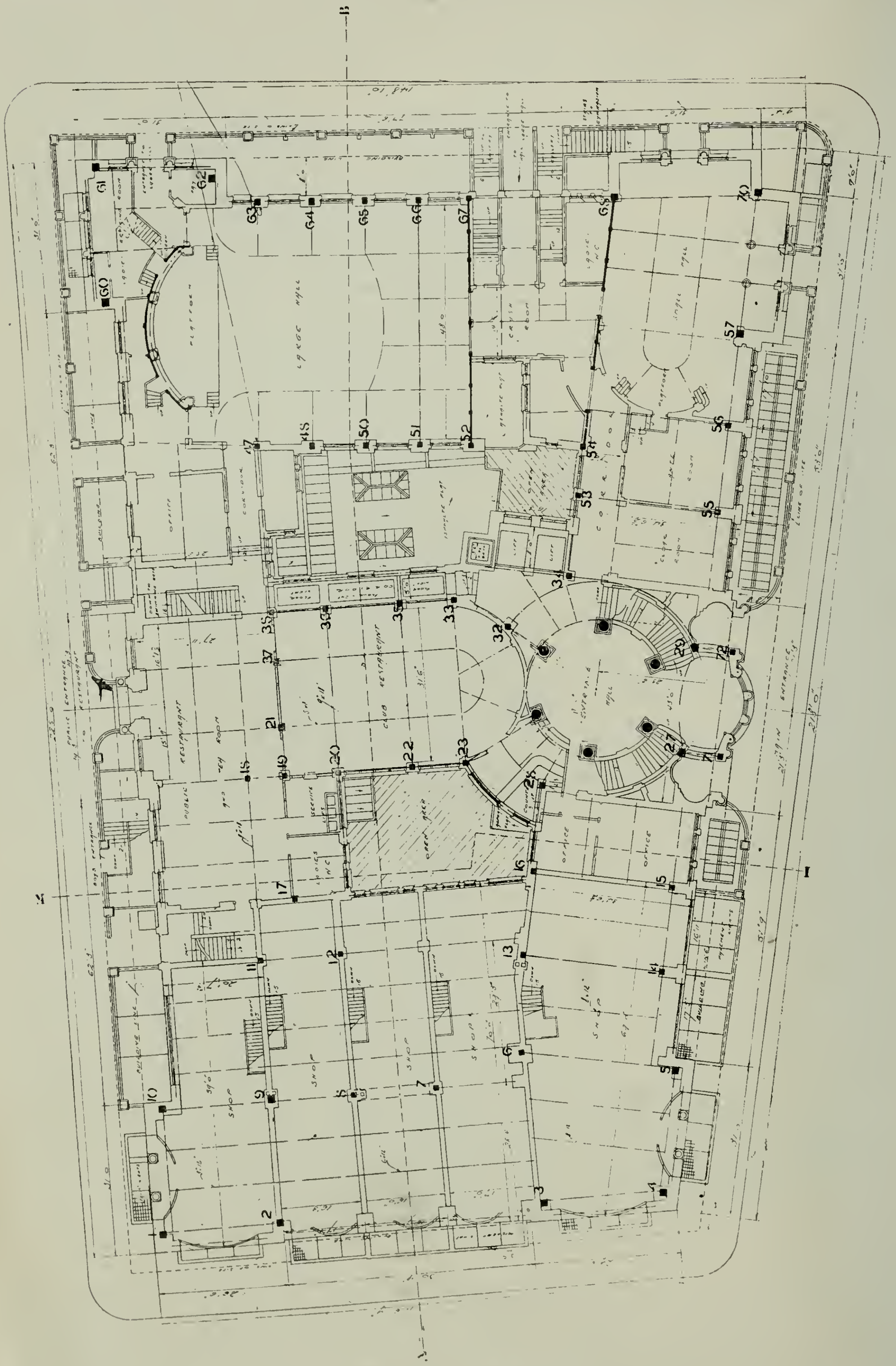


Fig. 2. Ground floor plan.
The New Central Y.M.C.A. Building.

connecting the vertical bars at intervals. The walls of the bath are very much assisted

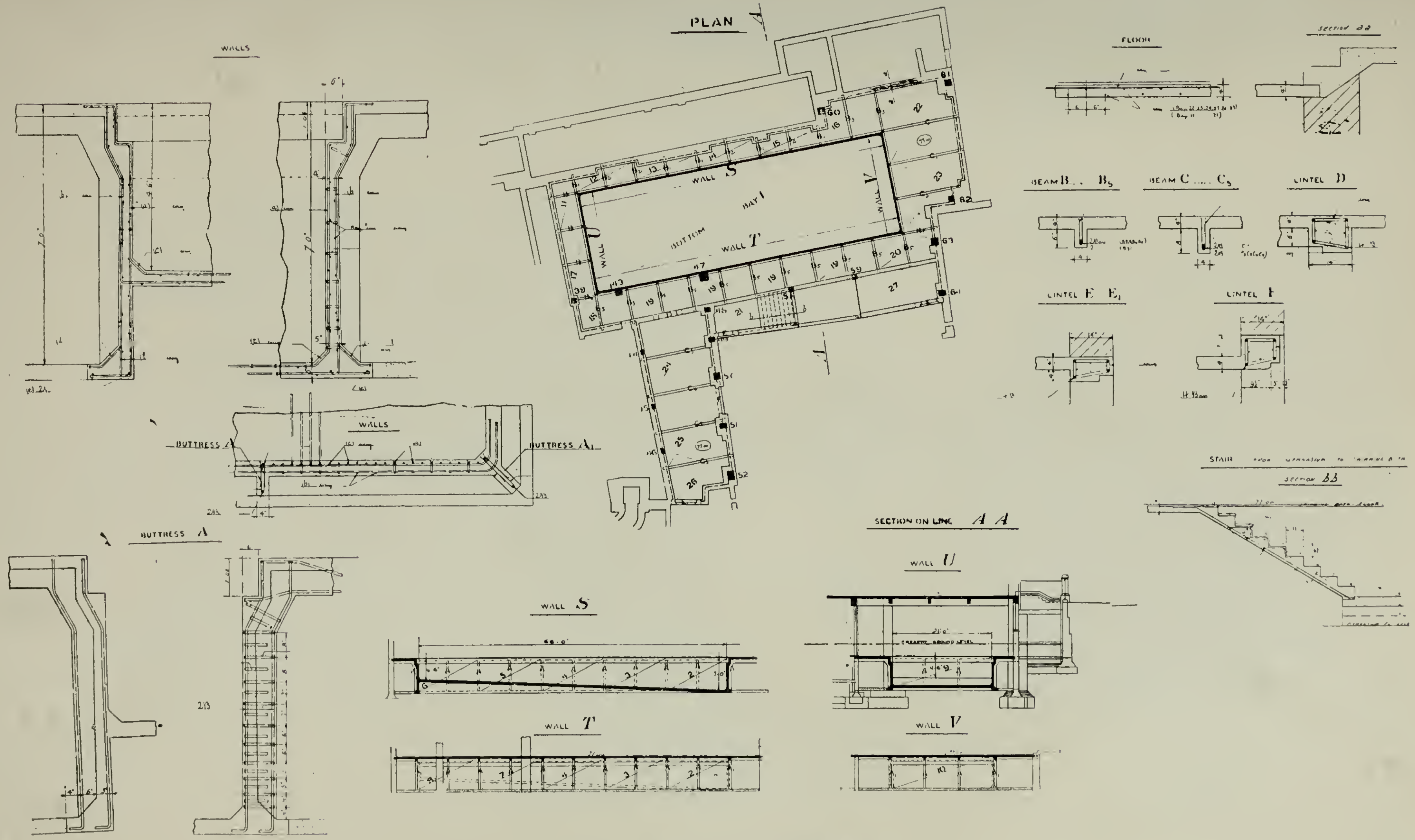


Fig. 3. Details of Swimming Bath.
The New Central Y.M.C.A. Building.

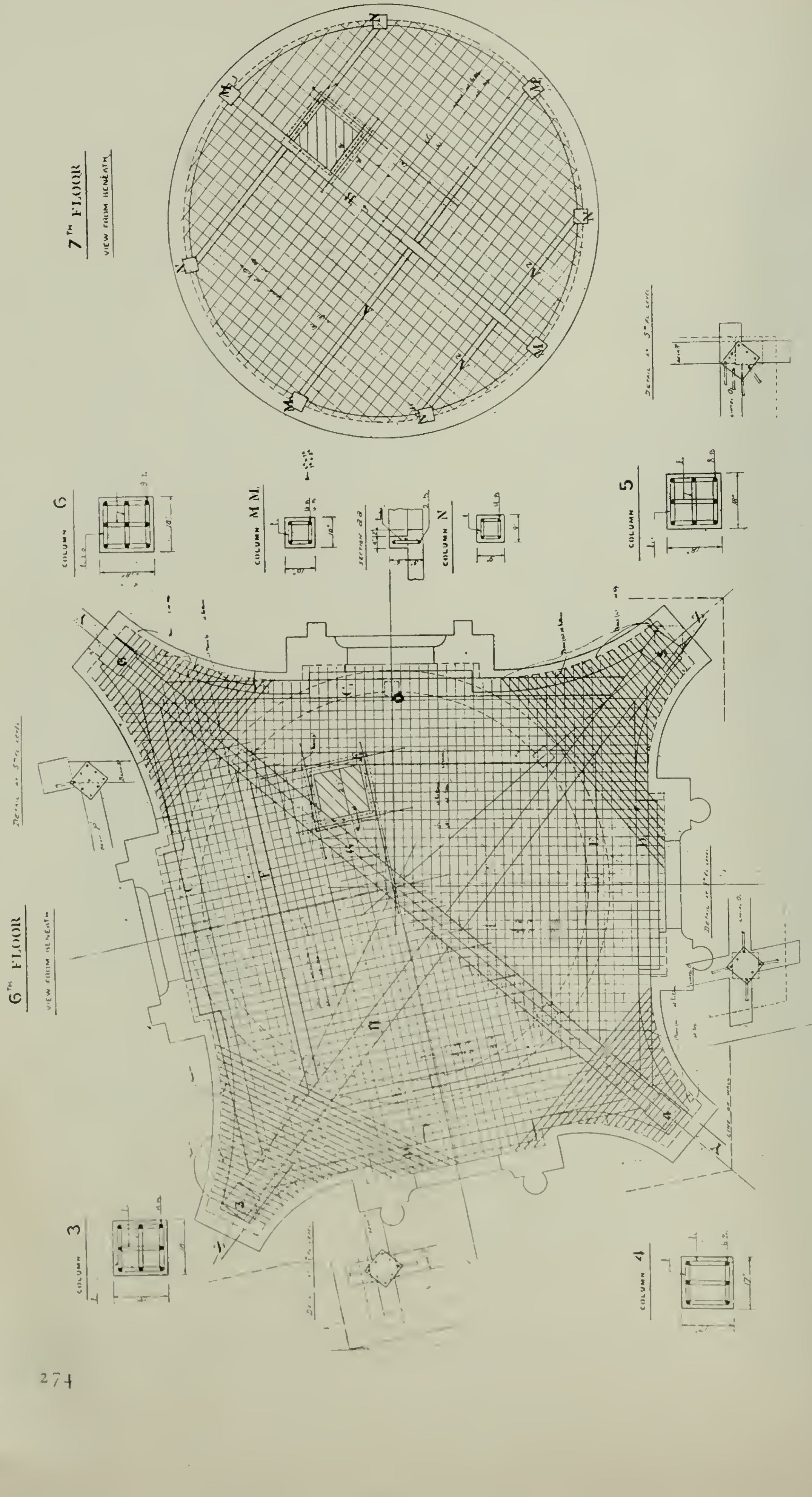


Fig. 4. Details of Tower.
THE NEW CENTRAL Y.M.C.A. BUILDING.

by the floor around the bath, which is connected to them and carried back to the walls of the apartment, thus forming one homogeneous structure, having great stiffness and strength.

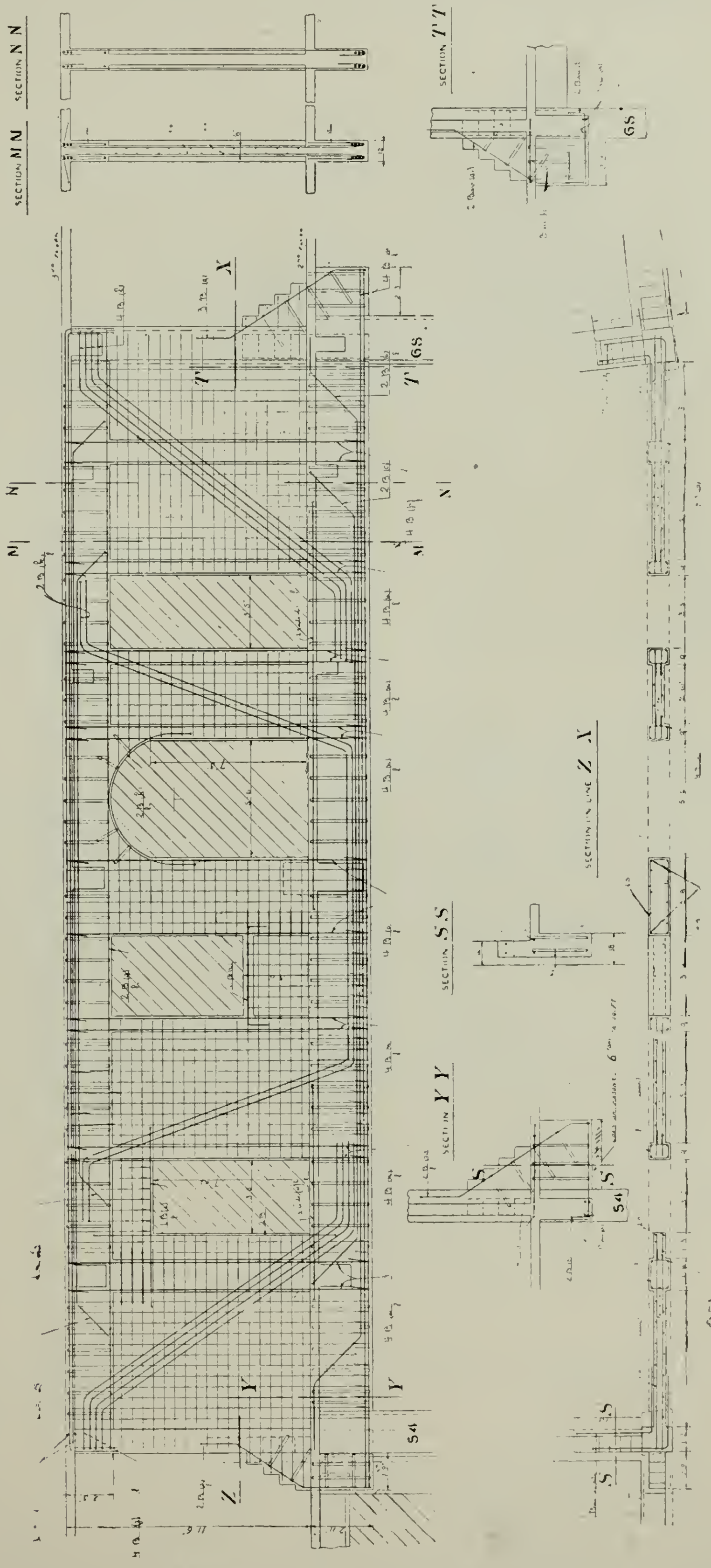


Fig. 5. Front elevations and sections.
The New Central Y.M.C.A. Building

The work in the gymnasium is particularly interesting on account of the large arched beams which are introduced to carry the floor of the large hall above, and which are visible in the ceiling of the gymnasium, as shown in the photograph in *Fig.* 10, taken after completion. This ceiling is divided up into panels 8 ft. square and 5 in. in thickness, with a lattice reinforcement of small rods, by five longitudinal beams and the large arched beams previously mentioned. The longitudinal beams extend the full length of the gymnasium from front to back, and these are supported by the arched ribs, which have an effective span of 50 ft. These ribs are 6 ft. deep at the springings and 2 ft. 2 in. deep at the crown, with a thickness of 12 in. throughout, the spandrils being pierced by two openings to reduce the weight as much as possible. In designing these ribs they were considered as T-beams fixed at the ends, as the floor slab above was continuous and reinforced in both directions, and in addition were stiffened by the longitudinal beams at intervals of 8 ft., and the condition of fixity was obtained by carrying the tension and compression bars in the rib well into the supporting columns, thus forming a monolithic structure. The reinforcement consisted of nine bars in the compression area, introduced in the thickness of the floor slab in sets of three, and nine bars in the tension area which follow the curve

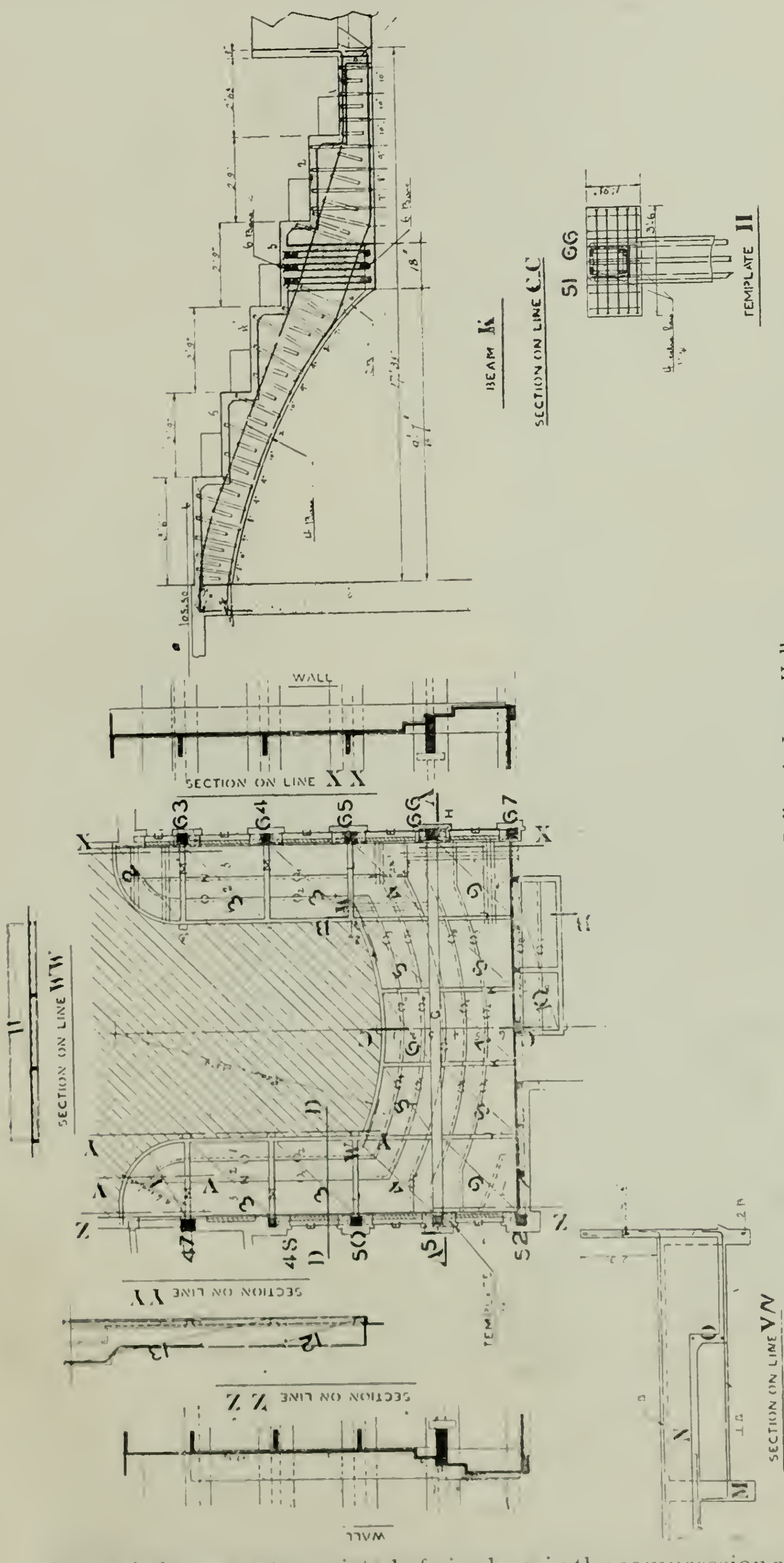


Fig. 6. Gallery in Large Hall.
The New Central Y.M.C.A. Building.

of the soffit. Vertical and diagonal bars were also introduced to connect the upper and lower parts, and additional reinforcement was provided, as necessary, around the openings formed in the spandrils. The main reinforcement is further supplemented

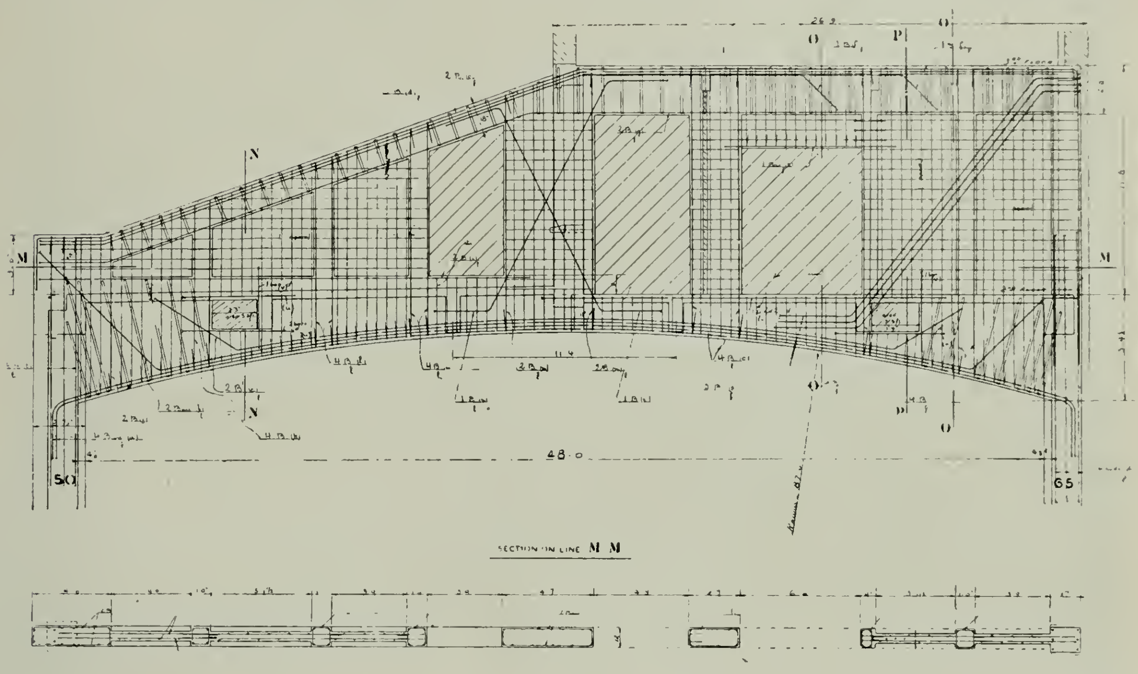


Fig. 7. Details of beam partition.

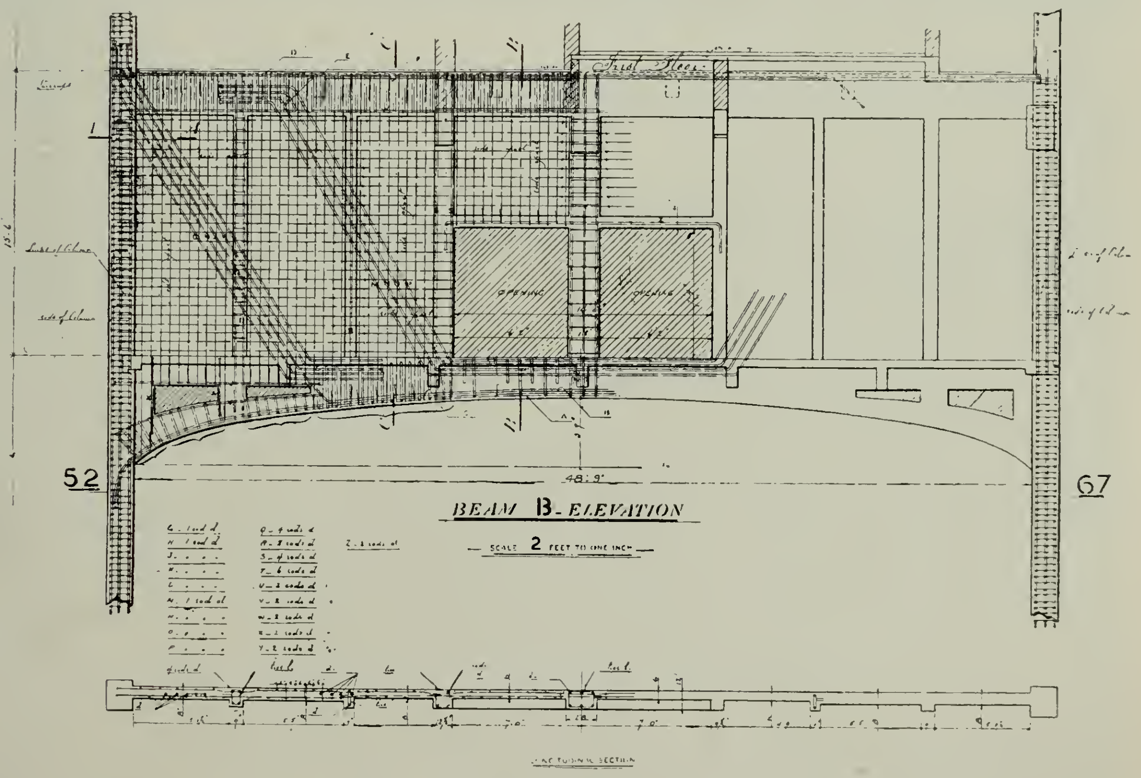
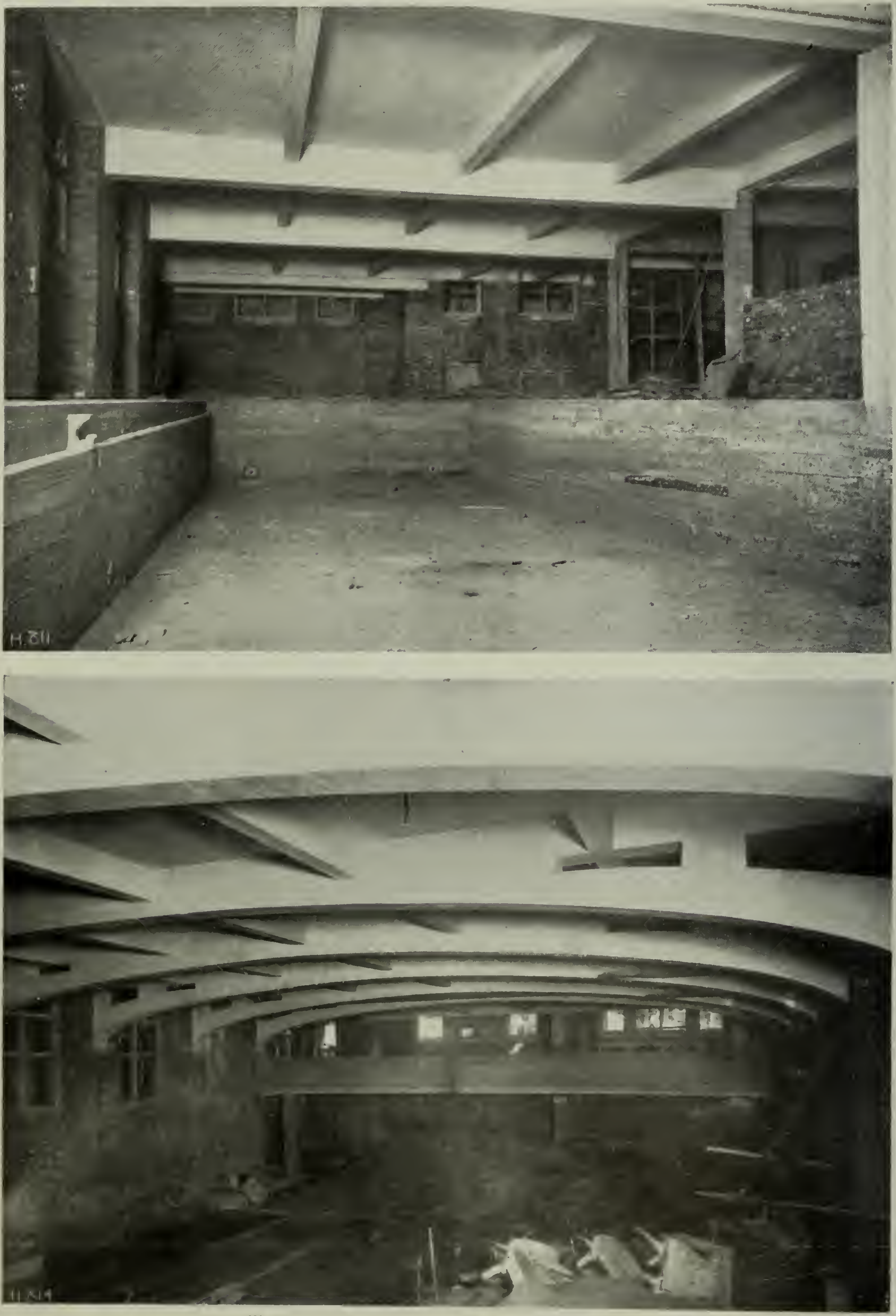


Fig. 8. Details of beam over Gymnasium.
The New Central Y.M.C.A. Building.

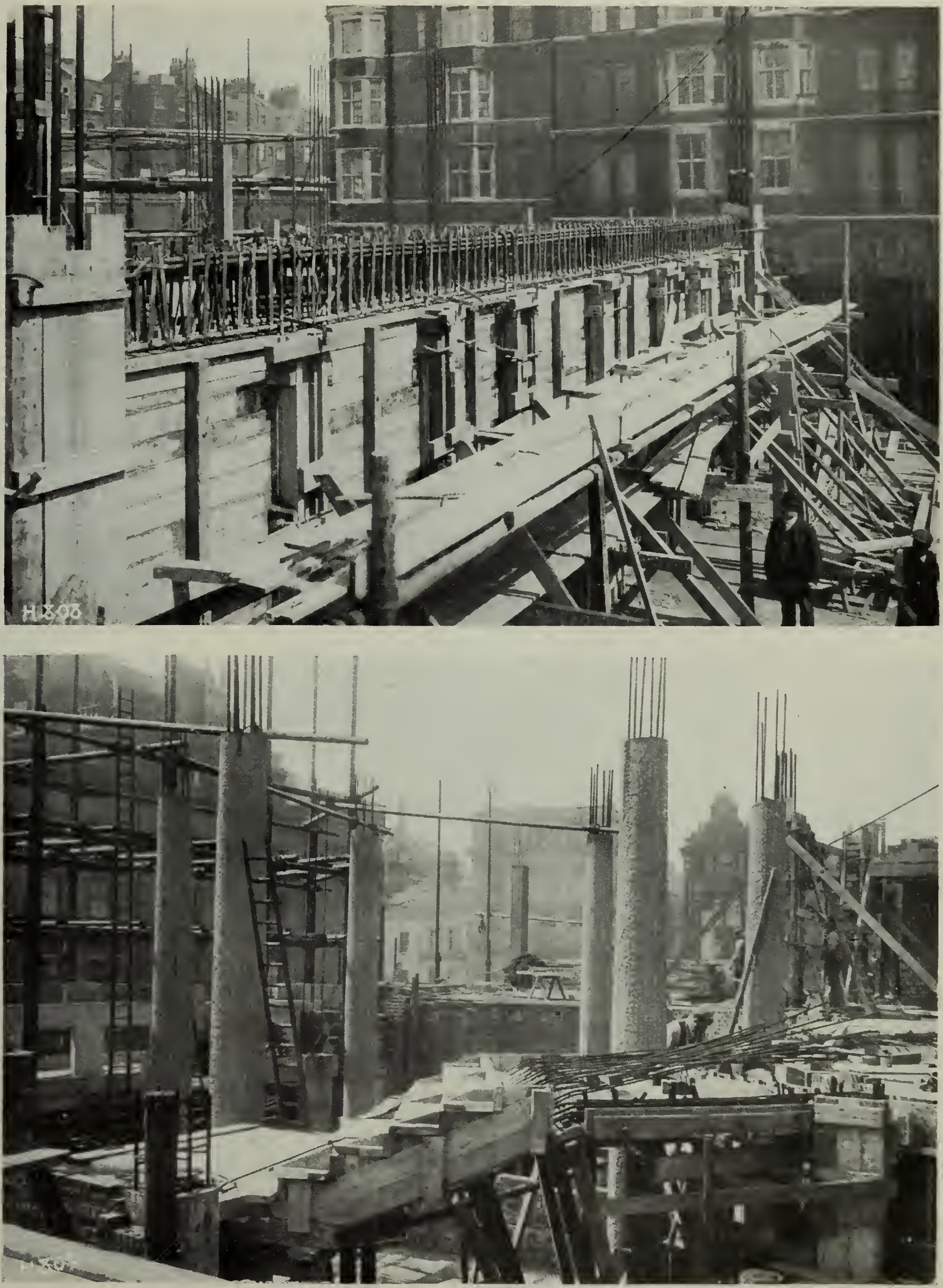
by U-shaped stirrups, which are bent round the longitudinal bars and carried well into the beam, and these stirrups are arranged in the manner most advantageous to resist the shearing stress and diagonal tension at the various points.

The beam partition illustrated in *Fig.* 8 shows one of the arched ribs just described



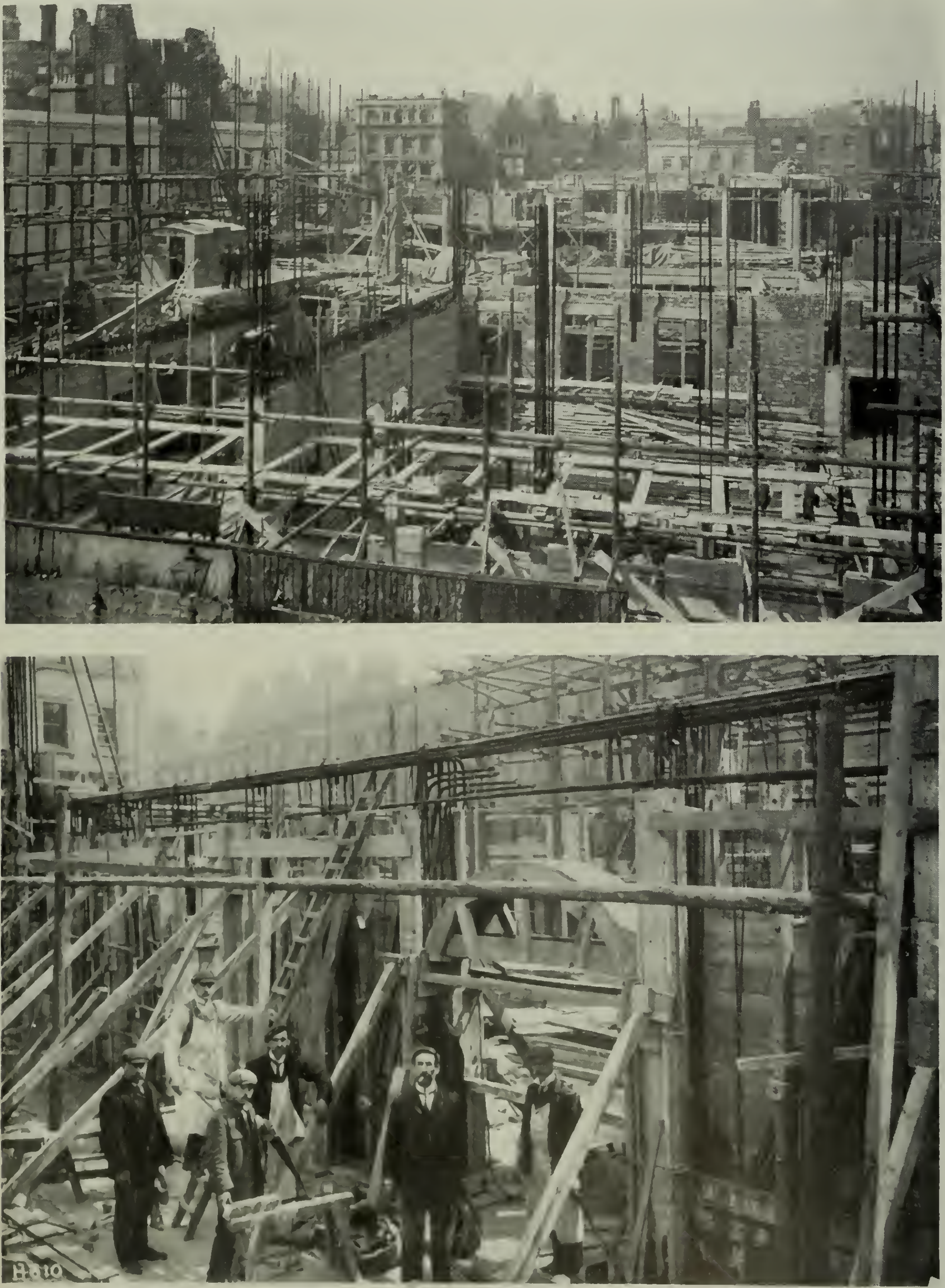
Figs. 9 and 10. Swimming Bath and Gymnasium
The New Central Y.M.C.A. Building.

in conjunction with the work above, this particular case occurring at the end of the main hall next the crush room. This instance is very interesting, on account of the way in which the partition has been utilised as a constructional feature, while allowing openings to be formed in same without detrimental effect on the strength. This trussed partition is extended through the ground floor to the first floor level, a height of 15 ft. 6 in., making a total height of 21 ft. 6 in. at the springing of the rib below.



Figs. 11 and 12. Constructing beam partition and Grand Staircase.
The New Central Y.M.C.A. Building.

thus forming an immense truss, capable of supporting a big load with comparatively light component parts. The lower flange is, of course, formed by the arched rib previously described, and the upper flange consists of a rectangular beam formed at the first floor level, reinforced with six rods in the upper surface and two rods in the under surface. The filling or web between the two flanges is formed by slabs 6 in. and 8 in. thick, reinforced by a lattice reinforcement consisting of rods in each surface,



Figs. 13 and 14. General view and centering for beam partition.
THE NEW CENTRAL Y.M.C.A. BUILDING.

and further stiffened by vertical stiffeners at intervals, as will be seen on studying the illustration of this beam. The photograph in *Fig.* 11 shows this work during execution. Two series of diagonal bars are also provided on each side of the openings formed in the centre of the partition. The columns supporting this work are 20 in. by 18 in., and reinforced with nine vertical bars tied together with steel links spaced at 4-in. centres.

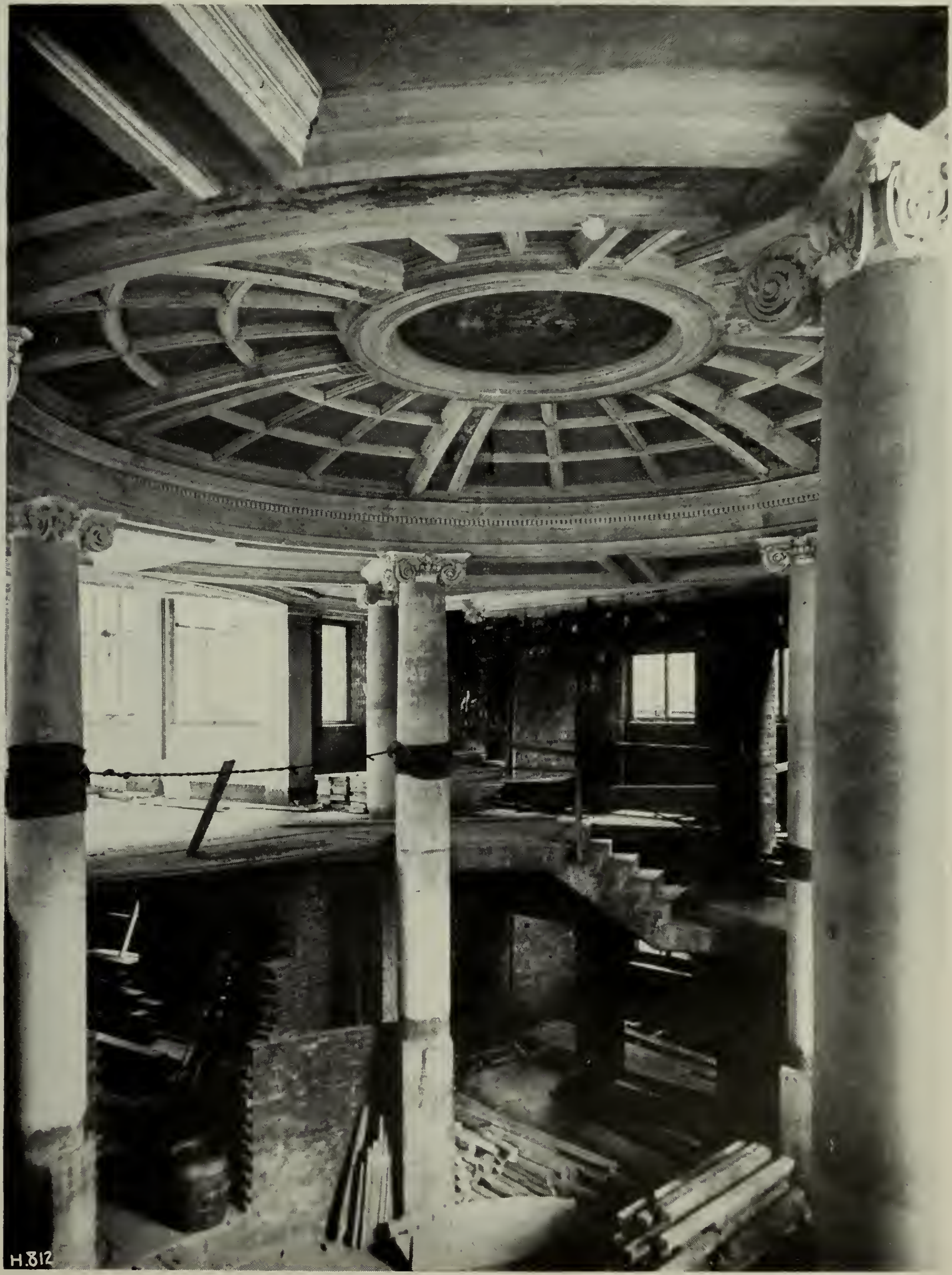


Fig. 15. Circular Staircase in course of construction.
THE NEW CENTRAL Y.M.C.A. BUILDING.

The illustrations in *Fig.* 6 show the work to the galleries in the main hall, and this is another instance of the adaptability of reinforced concrete where its monolithic character is of especial advantage. The side wings are carried by cantilevers, which depend entirely upon the anchorage into the reinforced columns to which they are connected, as they have no fulcrum beam to support them. The increased depth required near the support was obtained by utilising the space afforded under the raised tiers provided for seating purposes. The end portion of the gallery is supported on the trussed beam partition previously described, and the beam shown at G on the plan, the latter having an effective span of 50 ft., while beyond this beam the gallery is cantilevered for a maximum distance of 10 ft. The fulcrum beam, G, is 18 in. wide, and reinforced with six large rods in both upper and lower surfaces. This end portion of the gallery is connected up with the side wings, and the whole construction is monolithic and self-supporting, giving a clear space in the hall below. Some tests were conducted in this portion of the work, and the result is interesting as showing the elasticity of the material and the reliability of the work. The beam selected for the test was one of the beams in the side wing marked M, this having a cantilever of 10 ft. The area loaded was 10 ft. by 10 ft. 10 in., and the total load on this area was 165 cwt. One deflectometer was fixed at the outer edge of the cantilever, while another instrument was placed 1 ft. from the wall. The loading commenced at 10 a.m., and the whole load was removed at 4 o'clock. The greatest deflection occurred at the outer end of the cantilever, where it equalled $\frac{5}{256}$ of an inch, or only $\frac{1}{6142}$ of the span. Upon the removal of the load the cantilever regained its original position, and no permanent set occurred.

The grand circular staircase, which is shown during construction in *Figs.* 12 and 15, is entirely in reinforced concrete, being carried by transverse beams resting on reinforced concrete columns, and assisted in some cases by the surrounding walls. The soffit of the stairs is formed by a continuous slab 6 in. thick, reinforced by rods at 4-in. centres, and upon this the treads and risers are formed.

There are several instances of trussed beam partitions, some of which are illustrated by the drawings in *Figs.* 5 and 7. They form an excellent method of obtaining light and efficient construction over large spans, and the drawings are sufficiently explanatory without a detailed description of them. The whole of the roof construction throughout has been executed in reinforced concrete, including the dormers, these being probably unique. The tower, previously mentioned, has an internal diameter at the top of 13 ft. 6 in., and this is formed with 5 in. of concrete reinforced in both inner and outer surfaces, and on this the stone facing is carried.

This building affords a splendid example of the scientific design and application of a material capable of being employed to overcome extremely difficult problems in construction, thus rendering it possible to carry out ideals which, with any other material, would have been well-nigh impracticable.

The whole of the reinforced concrete work was designed by Messrs. L. G. Mouchel & Partners, in accordance with the Hennebique system, and this portion of the work was executed by Messrs. Holloway Bros., Ltd., the general contractors being Messrs. John Greenwood, Ltd.

THE NEUTRAL AXIS OF MEMBERS OF CIRCULAR SECTION.

By JOHN CASE, B.A.

The following article showing a method of finding the neutral axis of reinforced concrete beams of circular section may be of interest to those of our readers engaged in the design and calculation of reinforced concrete work.—ED.

In order to find the neutral axis of a reinforced concrete beam, we equate the total compression stress to the total tension stress, and assume that either stress is proportional to the distance from the neutral axis. Part of the problem resolves itself into finding the moment of the compression area about the unknown neutral axis. When the sections are rectilinear the problem is fairly easy, and the analysis simple algebra ; but in circular sections the compression area becomes the segment of a circle cut off by an unknown line, about which line (the neutral axis) we have to find its moment. This is more difficult, and as the subject does not seem to have been treated in the text-books, it is hoped that these notes will not be without interest.

The results will be particularly applicable to beams and columns of circular sections and pipes which are only supported at intervals.

The following analysis is carried out on the usual assumption that the reinforcing bars take the whole of the tensile stress, while the compressive stress is borne jointly by the steel and concrete.

Suppose that the reinforcement consists of $2p$ rods, of cross-section a, set in a regular polygon. Let the radius at which the rods are placed be r, which will also be taken as the radius of the section.*

Case I.—When the plane of bending passes through two of the rods (*Fig.* 1)

Oy is the plane of bending.

NS is the neutral axis.

Ox is parallel to NS and at right angles to Oy.

LM = distance of neutral axis from centre of section $= mr$, say.

Suppose there are $2q+1$ rods in compression, then the state of affairs will be as shown in *Fig.* 1, where the part of the concrete in compression is shown shaded.

$$AL = r\left(\cos\frac{\pi}{p} - m\right).$$

Compression stress on rod A

$$= nE_c\beta r\left(\cos\frac{\pi}{p} - m\right).$$

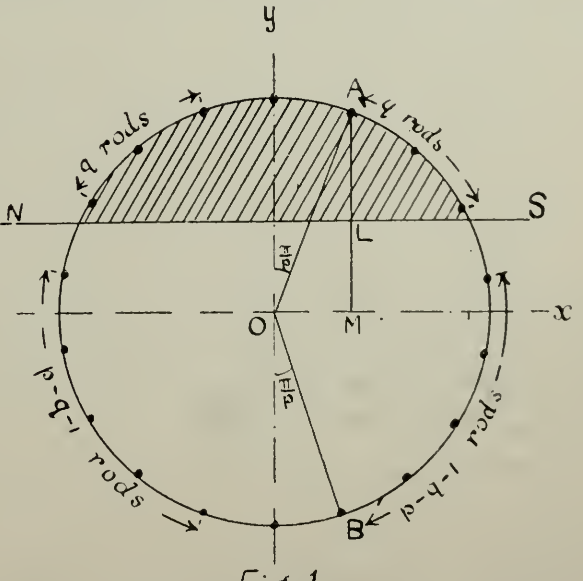


Fig. 1

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* This greatly simplifies the work without seriously impairing its accuracy.

Where n=ratio of moduli of elasticity of steel and concrete, and will be taken as 15.

β is a constant.

E_C=modulus of elasticity of concrete in compression, supposed constant.

Tensile stress on rod B $= n\,E_c\,\beta\,r\left(\cos\frac{\pi}{p}+m\right)$

and the compressive stress at any point in the concrete, distant η from the neutral axis$=\beta E_C\,\eta\,dx\,d\eta$.

Hence, equating the total compressive stress to the total tensile stress, we have

$$E_C\,\beta\iint\eta\,dx\,d\eta+2\beta\,E_C\sum_{S=1}^{S=q}n\,a\,r\left(\cos\frac{S\pi}{p}-m\right)+n\,a\,r\,(1-m)$$

$$=2\beta\,E_C\sum_{S=1}^{S=p-q-1}n\,a\,r\left(\cos\frac{S\pi}{p}+m\right)+n\,a\,r\,(1+m)$$

where the integration is taken all over the compressive area of the concrete. This equation reduces to

$$\iint\eta\,dx\,d\eta+2\sum_{S=q+1}^{S=p-q-1}n\,a\,r\cos\frac{S\pi}{p}=2\,p\,n\,a\,r\,m\quad.\quad.\quad.\quad.\qquad(1)$$

$$\text{Now}\quad\sum_{S=q+1}^{S=p-(q+1)}\cos\frac{S\pi}{p}=\frac{\sin\frac{p-2q-1}{p}\pi}{\sin\frac{\pi}{p}}\cos\frac{p\pi}{2p}=0$$

The integral

$$=2\int_0^{\sqrt{r^2-x^2}-mr}\int_0^{r\sqrt{1-m^2}}\eta\,dx\,d\eta,$$

since $\eta=\sqrt{r^2-x^2}-mr$

and $CQ=p\sqrt{1-m^2}$.

The value of the integral is

$$\frac{1}{3}r^3\,(7m^2+2)\sqrt{1-m^2}+mr^3\cos^{-1}m.$$

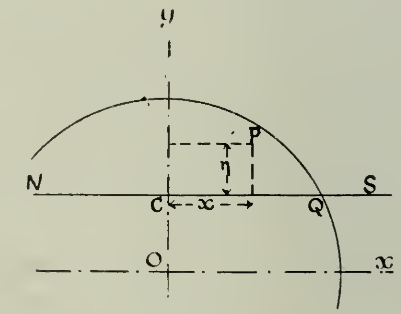


Fig 2.

Hence, from (i) we have

$$r^2\left\{\left(7m+\frac{2}{m}\right)\sqrt{1-m^2}+3\cos^{-1}m\right\}=6\,n\,a\,p$$

If r_1=radius of reinforcing bars$=kr$ say, this becomes, taking n=15,

$$\left(7m+\frac{2}{m}\right)\sqrt{1-m^2}+3\cos^{-1}m=283\,k^2\,p\quad.\quad.\quad.\quad.\quad.\qquad(2)$$

From this equation we can find m, which determines the position of the neutral axis. When this is found, we can calculate the moment of inertia by drawing in the ordinary way, q being determined by m. To calculate the moment of inertia, otherwise than by drawing, is very laborious, but for the sake of completeness its value is given below:

$$I=r^4\left\{\left(m^2+\frac{1}{4}\right)\cos^{-1}m-\frac{m}{12}\left(13+2m^2\right)\sqrt{1-m^2}\right\}$$

$$+2\,nar^2\left\{p-2q+\left(p-1\right)m^2\right\}+nar^2\frac{\sin\frac{2q-1}{p}\pi}{\sin\frac{2\pi}{p}}$$

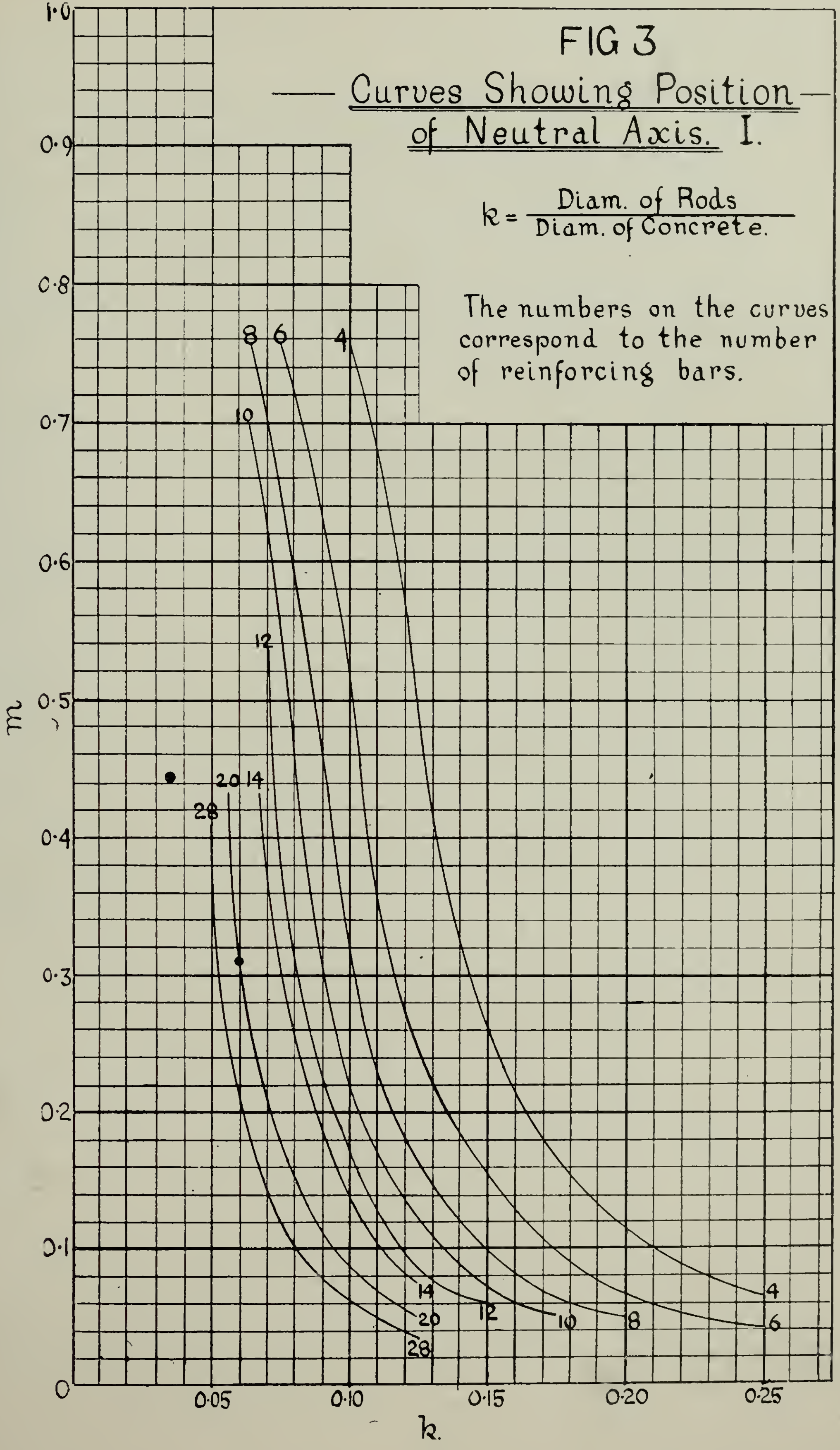


FIG 3

Curves Showing Position of Neutral Axis. I.

$k = \frac{\text{Diam. of Rods}}{\text{Diam. of Concrete.}}$

The numbers on the curves correspond to the number of reinforcing bars.

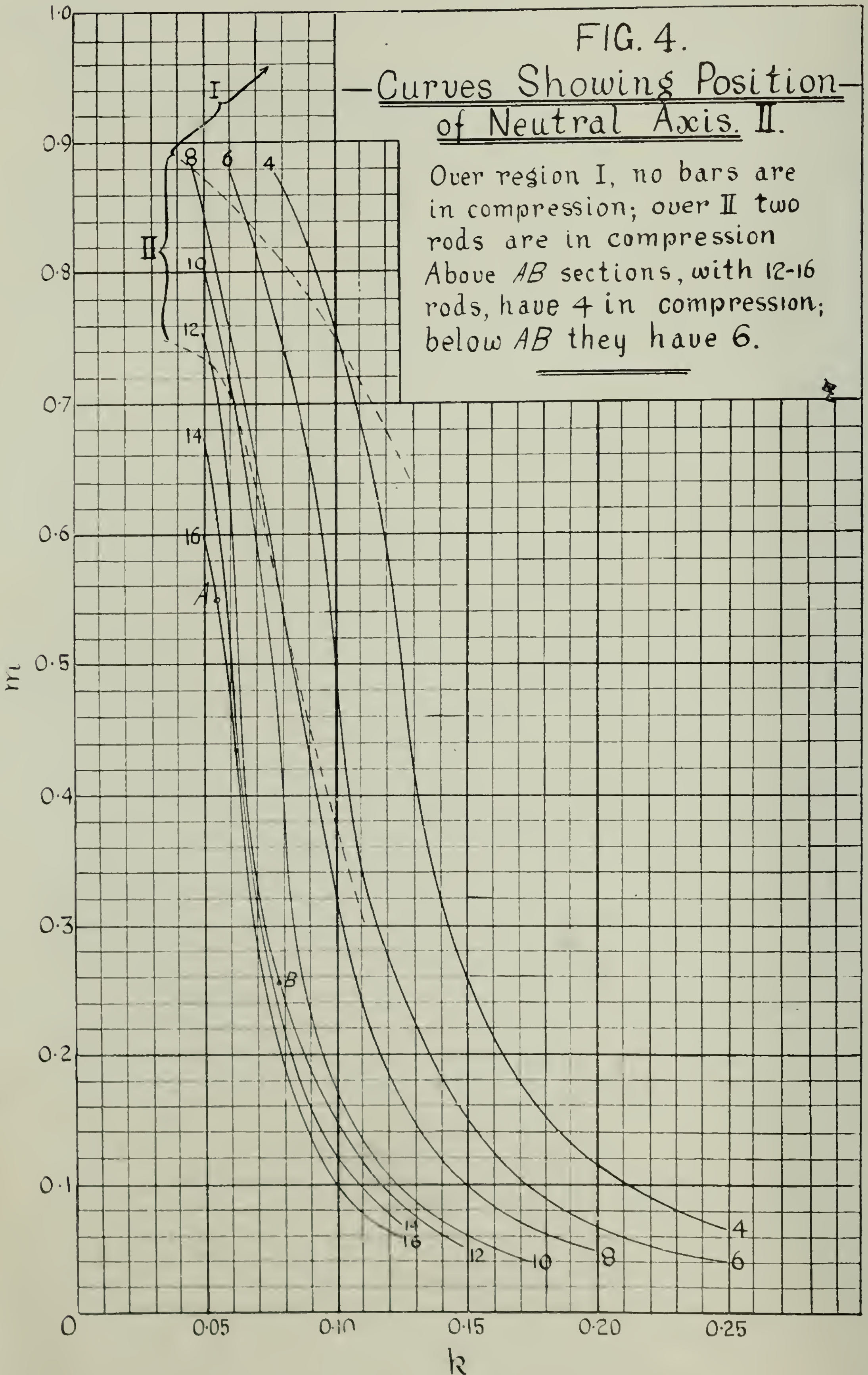


FIG. 4. —Curves Showing Position of Neutral Axis. II.

Over region I, no bars are in compression; over II two rods are in compression Above *AB* sections, with 12-16 rods, have 4 in compression; below *AB* they have 6.

Curves have been drawn in *Fig.* 3, showing the position of the neutral axis for different values of k and p, enabling the neutral axis for almost any arrangement of reinforcement to be determined at once. If we take the extreme height of the diagram—that is, from $m=0$ to $m=1$, to represent the radius of the section, the intersection of the ordinate corresponding to the given value of k, and one of the curves gives the required position of the neutral axis.

Example.—To find the position of the neutral axis of reinforced concrete column, 24 in. diameter, reinforced with eight 2-in. bars.

$$k=\frac{2}{24}=\cdot083.$$

Follow up the line $k=\cdot083$ until it intersects curve 8, where we find $m=\cdot57$.

Distance of neutral axis from centre $=\cdot57\times12=6\cdot8''$.

Case II.—When the plane of bending passes symmetrically between two rods (*Fig.* 5), $2q$ rods in compression, and $2p-2q$ in tension.

Proceeding in exactly the same way as before, we obtain an equation for finding m:

$$\left(7m+\frac{2}{m}\right)\sqrt{1-m^2}+3\cos^{-1}m = 283\,k^2\left(\frac{\sin\dfrac{2q\pi}{p}}{\sin\dfrac{\pi}{p}}+p\right) \qquad (3)$$

In this equation q is not arbitrary, but is settled by m. As before, curves have been drawn (*Fig.* 4) showing the relation between m and k, and also the number of rods in compression.

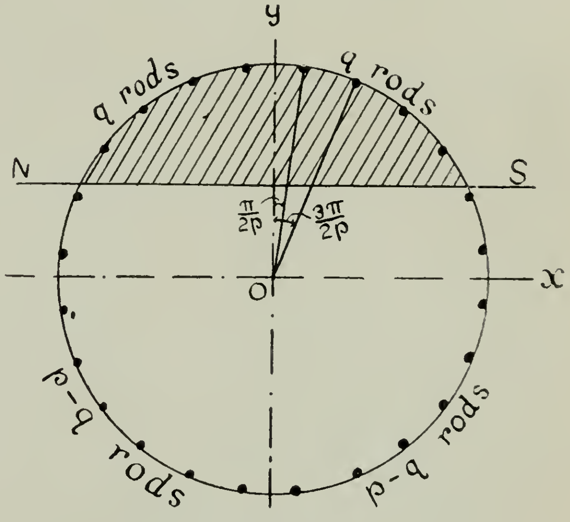


Fig. 5.

HOLLOW CIRCULAR SECTIONS WITH REINFORCEMENTS.

r=mean radius of section and radius at which the rods are set.

t=thickness of concrete, so that $r\pm\frac{t}{2}$ are the internal and external radii of the concrete.

The area of concrete in compression $=2r\theta t$, if t be small compared with r.

The distance of the c.g. of the area from $O=\dfrac{r\sin\theta}{\theta}$

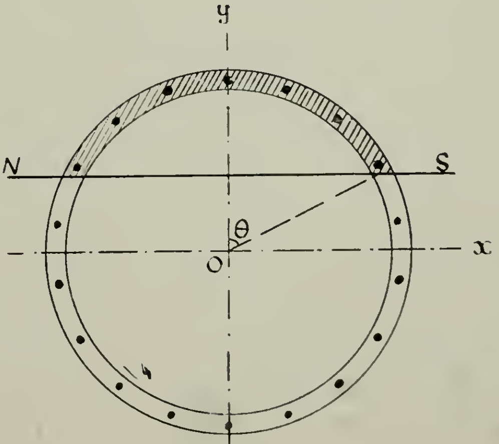


*Fig.*6.

The moment of compression area about NS

$$= 2r^2\theta_t\left(\frac{\sin\,\theta}{\theta} - m\right) = 2r^2t\left(\sqrt{1 - m^2} - \mathrm{m}\cos^{-1} m\right).$$

I. When the plane of bending passes through two rods.

Proceeding as before, we obtain

$$2\,r^2t\,(\sqrt{1 - m^2} - m\cos^{-1}m) = 2\,p\,n\,a\,r\,m$$

or

$$rt\,(\sqrt{1 - m} \quad - m\cos^{-1}m) = n\,a\,m\,p$$

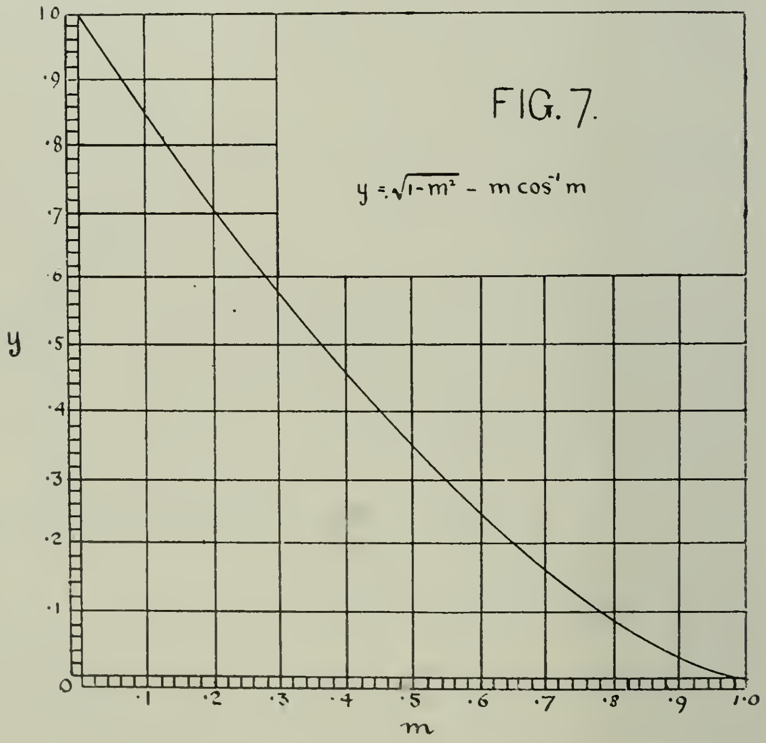
$$\sqrt{1 - m^2} - m\cos^{-1}m = 47{\cdot}2\,m\,r\,p\,k^2/t \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (4)$$

which equation enables us to obtain the position of the neutral axis for any given arrangement.

II. When the plane of bending passes symmetrically between two rods, we find

$$\sqrt{1 - m^2} - m\cos^{-1}m = 47{\cdot}2\,\frac{rk^2}{t}\left(\frac{sin\,\dfrac{2\,q\,\pi}{p}}{sin\,\dfrac{\pi}{p}} + mp\right) \quad . \quad . \quad . \qquad (5)$$

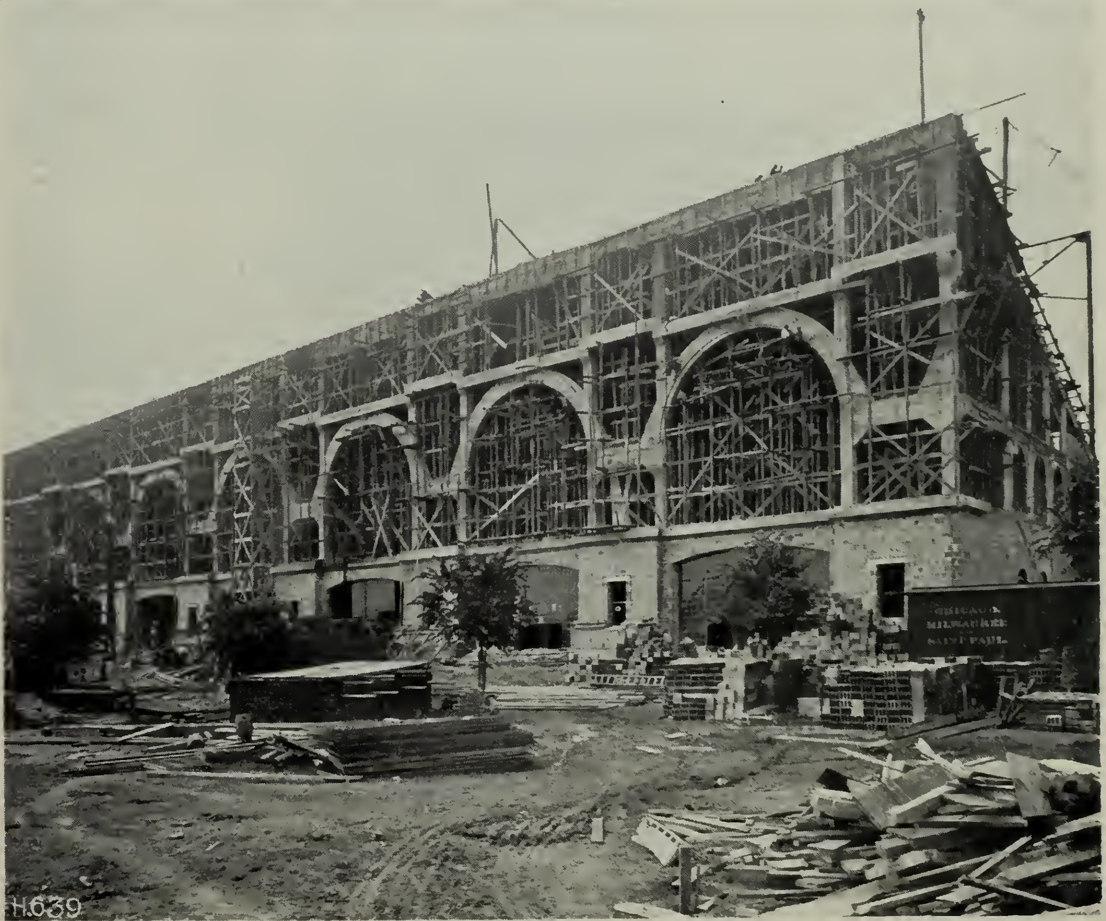
which, again, determines the position of the neutral axis. To simplify calculations in these two cases the left-hand side of (4) and (5) has been plotted in *Fig. 7.*



REINFORCED CONCRETE GRAND STAND AT ST. PAUL, MINNESOTA.

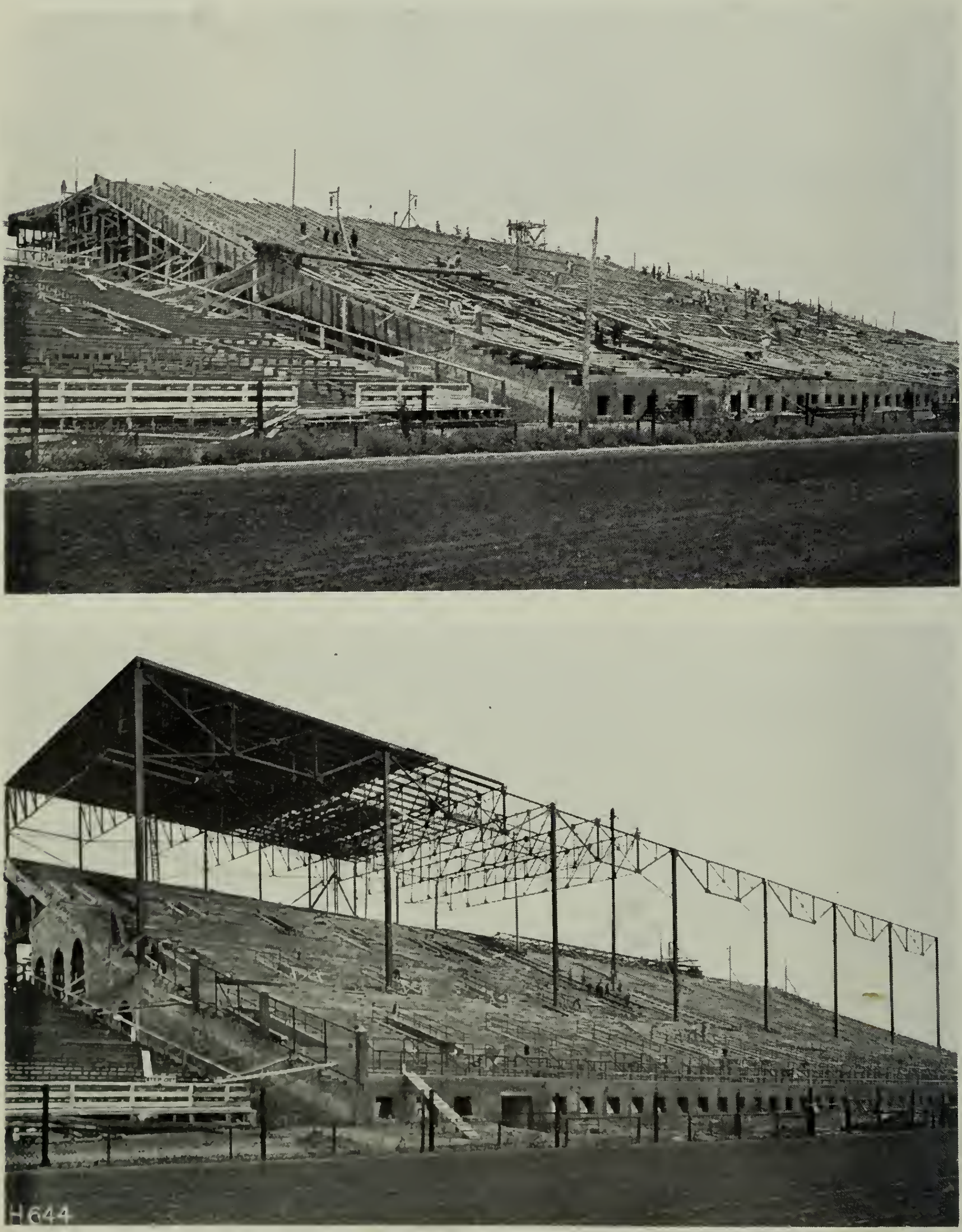
The following account of the construction of a large reinforced concrete Grand Stand in America should claim attention. Our particulars are taken from "Engineering Record," the photographs and drawings having been kindly lent us by Messrs. Reed & Stem of St. Paul, Minnesota.—ED.

THE Grand Stand at the Minnesota State Fair race-track, St. Paul, is a reinforced concrete structure 800 ft. long, 240 ft. wide, and 105 ft. high, with 60 tiers of seats and two rows of boxes, having a seating capacity of about 30,000. The upper floor is an inclined platform of the full width and length of the building, made up of narrow longitudinal horizontal sections, each of them wide enough for a single row of chairs.



Stand in Course of Construction.
REINFORCED CONCRETE GRAND STAND, ST. PAUL, MINN.

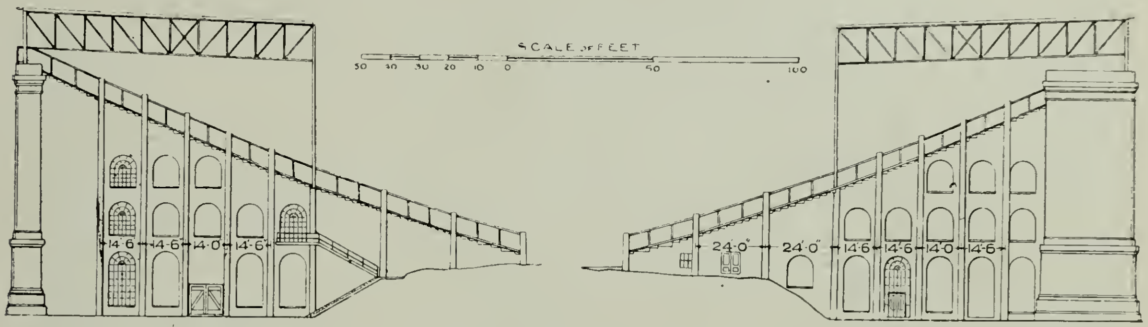
This is covered by fixed and movable roof panels supported on steel trusses and steel columns, and under it there are from one to four storeys of exhibition rooms, offices, etc., with corridors, galleries, and wide stairways. The finished structure will consist of 15 duplicate panels, and will cost nearly $500,000 (£100,000).



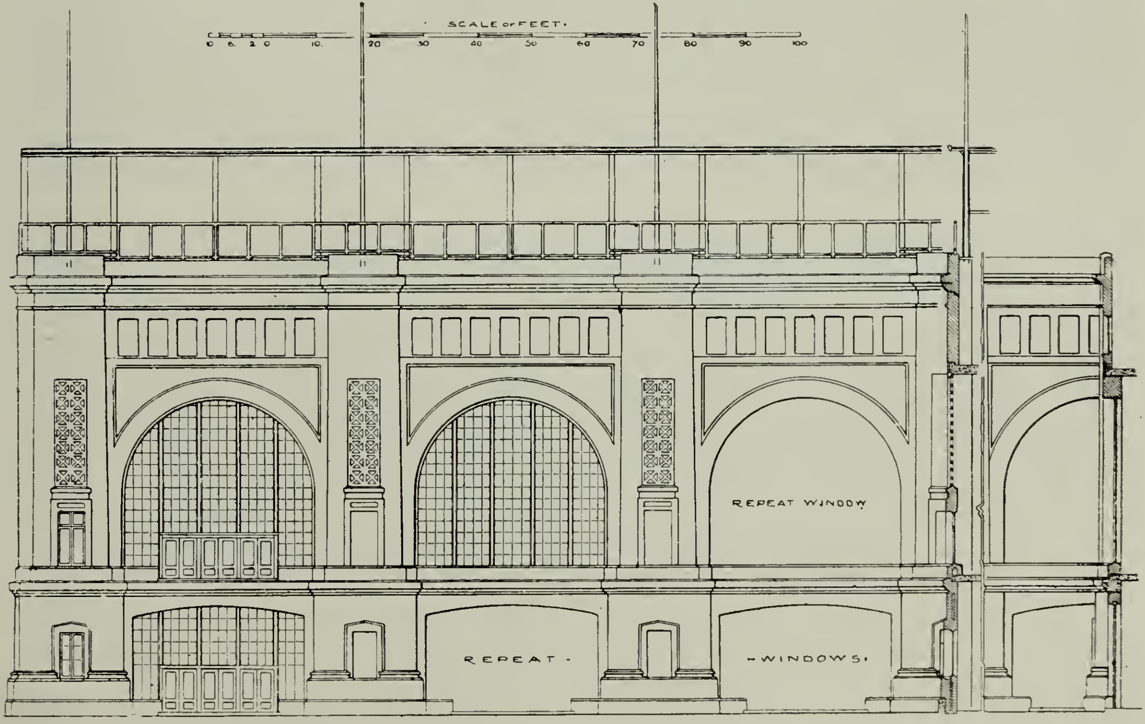
View Showing Work in Progress.
Reinforced Concrete Grand Stand, St. Paul, Minn.

Foundation pits were dug to a maximum depth of about 8 ft. in the dry, hard sand, sheeted as necessary, and reinforced concrete piers of maximum widths of about 10 ft. were built in them for the footings of 156 columns. Centering was immediately erected for the whole of the first storey, and as the concreting progressed from one end of the building to the other the second-storey falsework and centering were built on it, advancing in the same direction and simultaneously with that of the first storey.

It was found to be advantageous to complete concreting each floor before commencing to concrete the next upper floor, but the work was pushed continuously by day and night shifts, and most of the centering and falsework was left in position until all of it was finished, thus avoiding any delay or confusion from shifting or repairing forms.

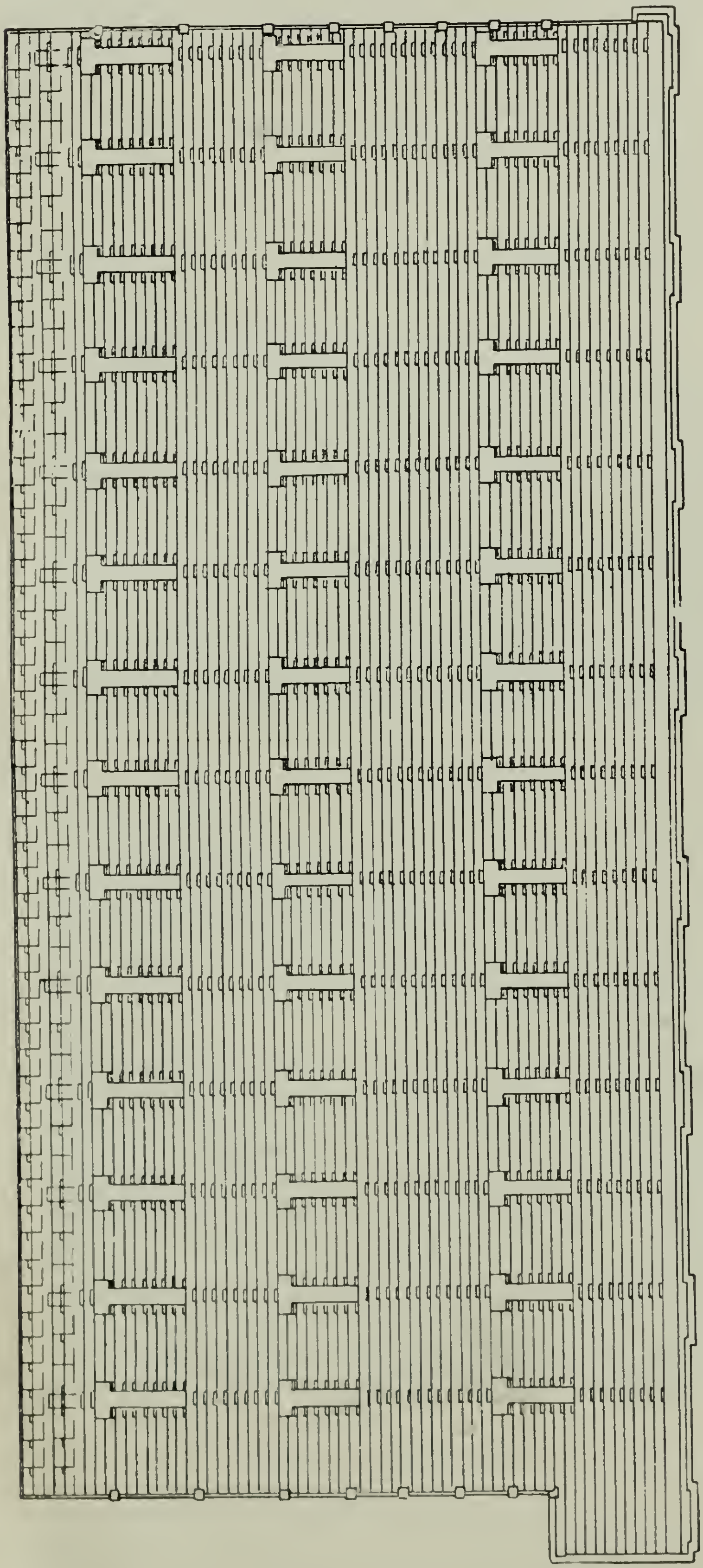


East and West Elevations.
REINFORCED CONCRETE GRAND STAND, ST. PAUL, MINN.



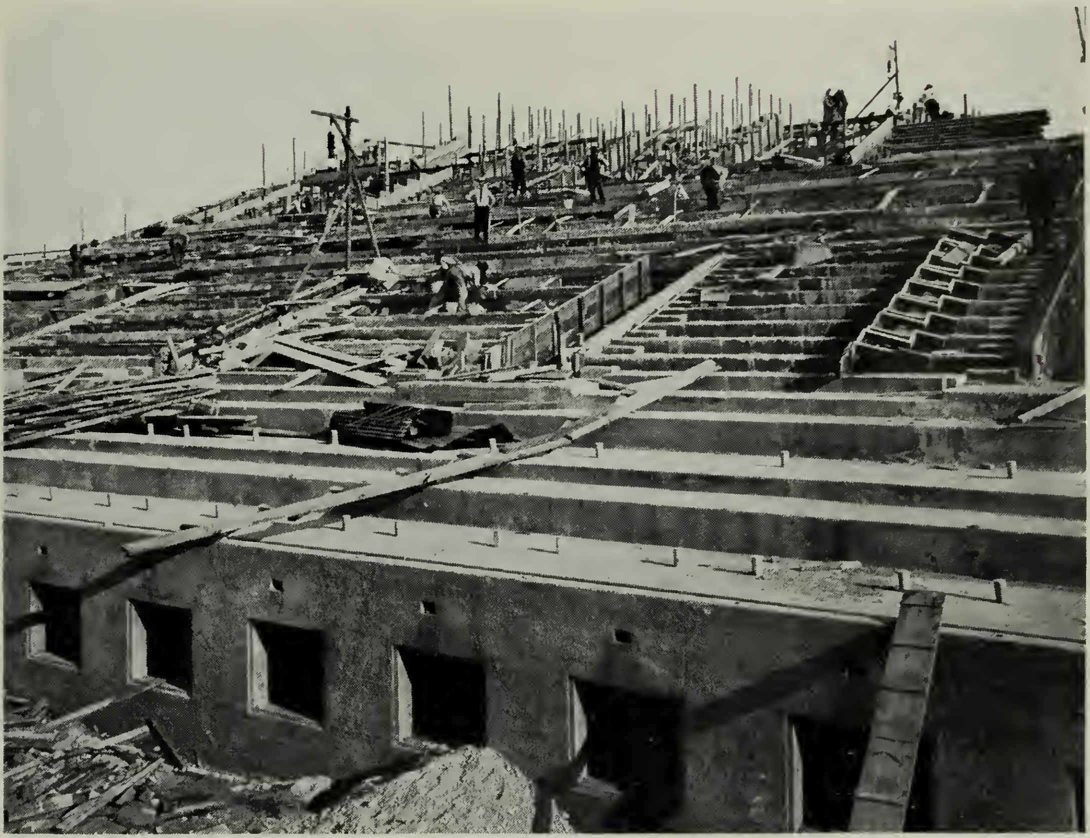
Half Elevation to Street
REINFORCED CONCRETE GRAND STAND, ST. PAUL, MINN.

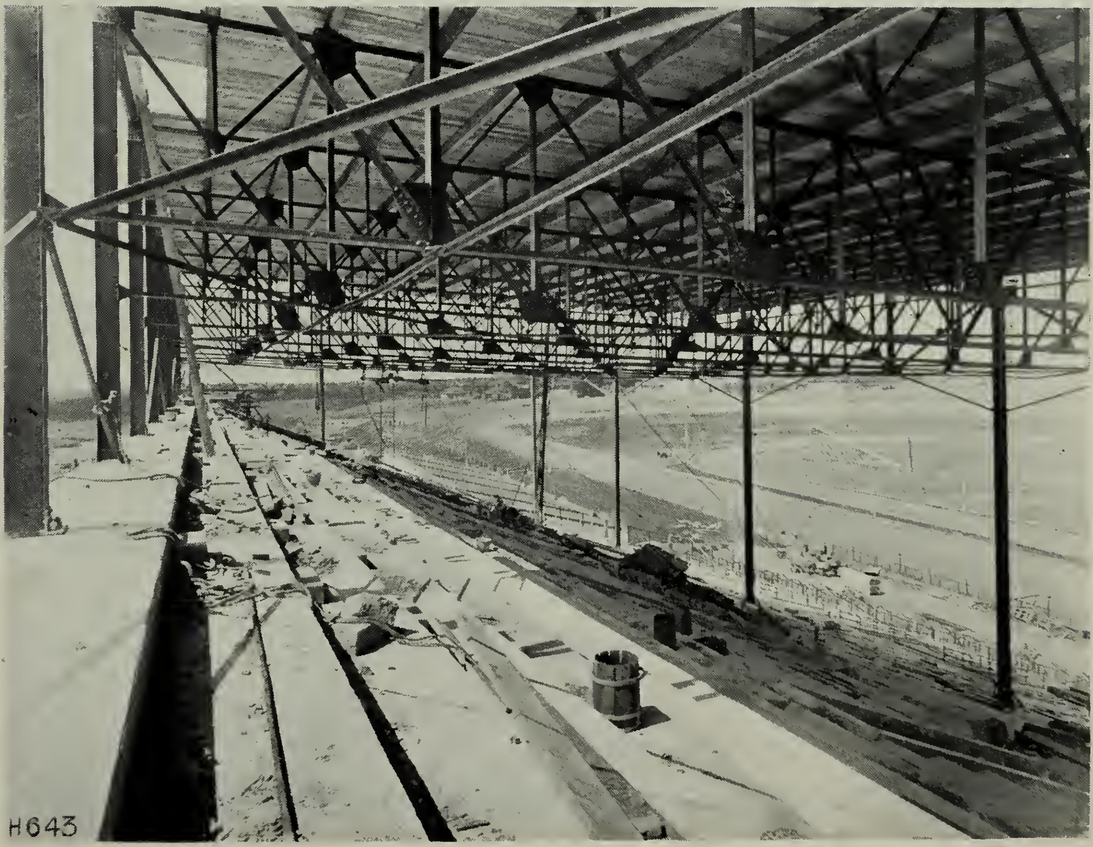
Foundation work and excavating were prosecuted simultaneously and as rapidly as possible, and as soon as the foundation piers at one end of the building were old enough, column forms were set on them and falsework and centering for the first storey of the grand stand were erected. The columns, which have spiral and vertical reinforcement, are all of them cylindrical except in the walls. They were cast in knock-down steel forms, made in telescope sections about 5 ft. long, of No. 20 unriveted sheets, overlapping about 4 in. on horizontal seams and 3 in. on vertical seams, and clamped in position by hinged collars of 4 in. by $\frac{3}{16}$-in. steel with a hasp-like connection locked by a tapered key. Wooden fillers, about 3 in. thick, were inserted between the collars and the steel sheets, for the purpose of stiffening the joints, which, when made in this manner, were very satisfactory. The knee-brace sections between the columns and girders were made by extensions from the wooden forms of the latter. The rectangular wall columns were cast in regular wooden forms with vertical panels secured by horizontal yokes and tie-rods.



Seating plan.
Reinforced Concrete Grand Stand, St. Paul, Minn.

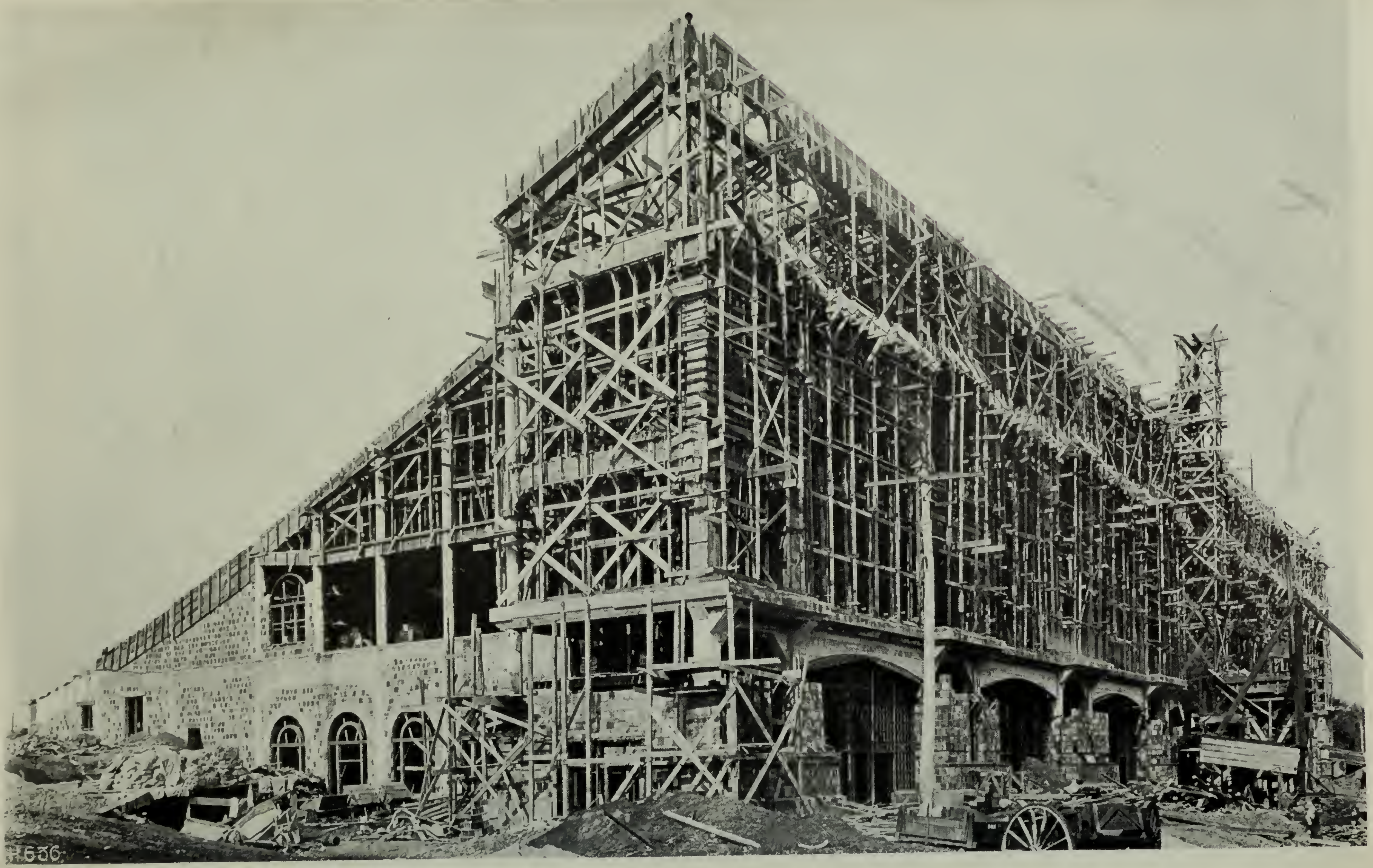
Beam and girder forms of the usual trough type were erected, and served, together with intermediate shores, to support narrow horizontal boards placed between the centres of the hollow tile floor blocks to close the spaces between them and carry them and the concrete filling and reinforcement rods for the floor slabs. Pieces of tile and scrap ends of reinforcement rods were placed transversely in the girder forms to maintain the reinforcement rods above the soffits of the floor slabs, and great care was taken to wire the rods where necessary and maintain them in accurate position until concreted.





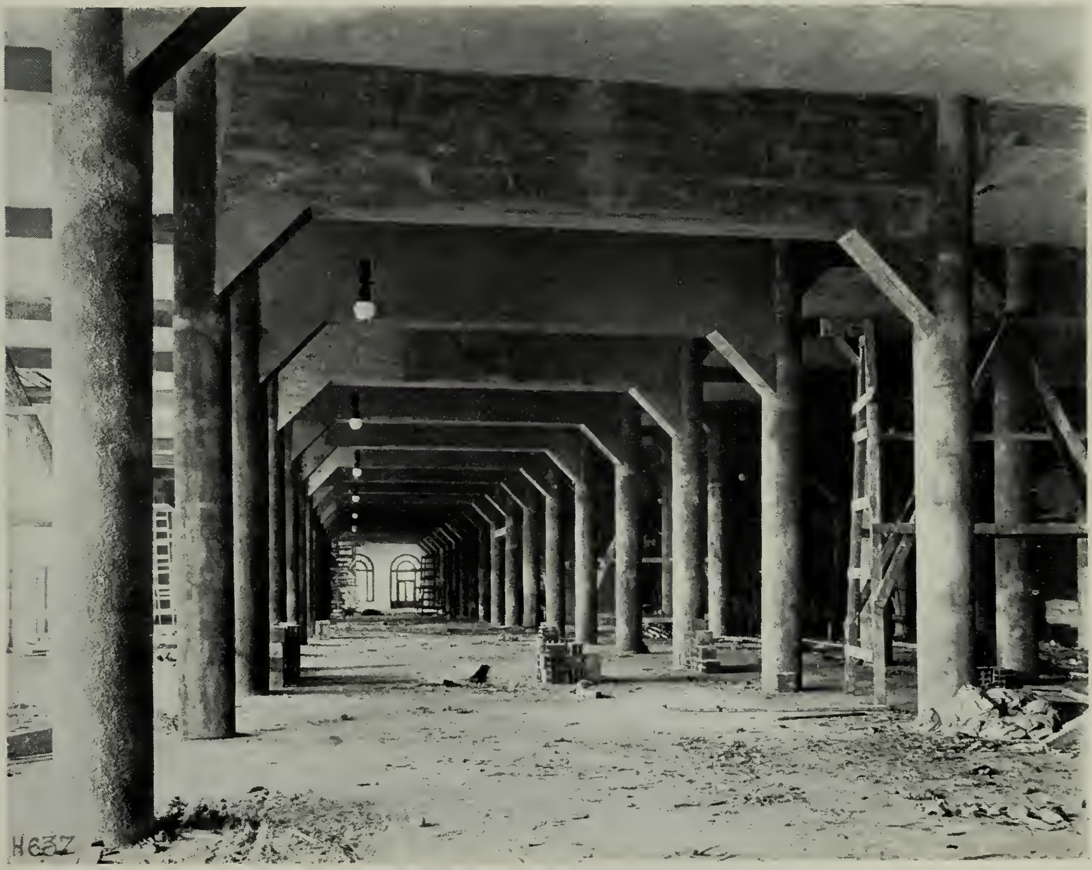
Views showing Stand in Course of Construction and Underside of Roof.

Reinforced Concrete Grand Stand, St. Paul, Minn.



Stand in Course of Construction.
Reinforced Concrete Grand Stand, St. Paul, Minn.

The dowels in the foundation piers and the tops of the reinforcement bars in the successive storeys of the columns projected above floor level and rods in the next storey were connected to them by sleeves about 2 ft. long. The upper ends of the rods were generally held in position by wooden templates at their extremities about 2 ft. above the surface of the floor, thus providing clearance for delivering concrete under them to the column moulds while the templates were in position. Sometimes the reinforcement bars were also stayed intermediately, but this was not generally necessary, especially in the hooped columns where the spiral reinforcement prevented them from moving too far out, and the action of the concrete tended to separate them as widely as possible, which was considered within limits to be desirable. When the top templates were omitted the rods were liable to become considerably displaced and cause difficulty in centering those of the column above. The reinforcement steel was generally received cut to length and was sorted and stored on the ground.



Columns under Grand Stand.
Reinforced Concrete Grand Stand, St. Paul, Minn.

As fast as the beam and girder forms were set for successive bays a 24-in. gauge Koppel service track was installed on it, parallel to the axis of the building and close to the elevator tower and switches. Parallel tracks and spurs were connected with it as necessary. The concrete was hoisted in buckets, automatically dumped through chutes into the side-dump cars of the service track, and these cars delivered to the column and girder mould or to the slabs through tapered chutes like those used for the foundation piers, and thus generally placed the concrete where required without shovelling and eliminated handling other than spreading and a little tamping. Work was carried on by one 10-hour day shift and by a night shift working from 7 p.m. to 7 a.m., by the light of arc lamps. Forms were built in the day shift only, but the other work was carried on at night, and as much as 350 yd. of concrete were thus placed in 24 hours by about 20 men each in the day and night shifts.

The terrace steps in the upper platform were cast on full-size sheets of corrugated iron bent at right angles to make the tread and riser with a single continuous piece, and supported at frequent intervals on horizontal transverse pieces forming parts of triangular offsets nailed to the upper sides of falsework beams inclined parallel to the slope of the platform.

Considerable difficulty was at first experienced by the weight of the wet concrete producing a heavy downward lateral thrust which deflected the riser forms and made the lines of the finished concrete irregular and curved. This was corrected by the use of a tier of very heavy upper inclined beams, to which the riser forms were secured like those of the supporting forms below. The lower ends of the upper inclined beams engaged a heavy horizontal girder tied back at frequent intervals by horizontal tension rods transferring the thrust across the building to very heavy columns or other members competent to provide suitable reaction.

In the aisles the high risers were provided with auxiliary steps about 3 ft. wide and 8 ft. long. These were at first cast in forms to be monolithic with the rest of the floor slabs, but it was later found to be much more satisfactory to cast them separately in the yard as solid slabs, which were afterwards set in place and grouted. All the floor slabs were finished and cast at one operation with rich concrete carefully floated to make a smooth, regular surface, and leave a perfectly homogeneous mass, thus avoiding the subsequent application of a veneer surface. Perfectly solid, sound surfaces were thus secured, and were considered satisfactory, although the extra amount of floating brought a little more water than usual to the surface, and sometimes caused very shallow pitting, which, however, was not considered serious.

All soffits were plastered with cement mortar applied directly to the rough tile surfaces, and a pleasing, uniform texture and colour was secured for all columns and other exposed concrete surfaces by stippling. This was accomplished by dipping a bunch of stiff twigs in grout of the consistency of cream, and striking it sharply with a rod, causing the thick liquid to spatter over the adjacent surface, practically covering it with small separate drops. When the stippling was performed on a dry concrete surface it was not found to be durable, but if the surface was first thoroughly wet with clean water the grout adhered permanently.

The work involved about 109,000 sq. ft. of tile, 580 tons of reinforcement and 8,000 cu. yd. of concrete, containing 9,000 barrels of Portland cement and 8,000 yd. of broken stone and gravel.

The architects were Messrs. Reed & Stem of St. Paul, Minn. Mr. G. J. Grant was the general contractor. Structural steel was furnished by the Phillip W. Herzog Co., St. Paul; reinforcement steel by the Trussed Concrete Steel Company.

CONCRETE MIXERS.

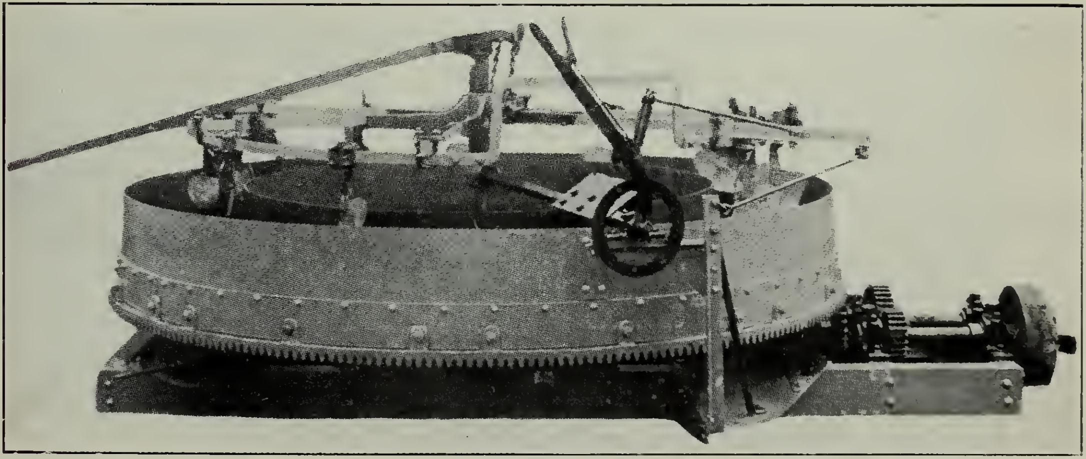
In some former issues we published articles on the different appliances for concrete making, and we now intend giving a further series of articles on additional concrete mixers.—ED.

THE "PANSY" CONCRETE MIXER.

THE design and construction of the "Pansy" Concrete Mixer, of which we give an illustration below, are simple, and it is easily worked, one of its special advantages being that the whole of the mixing operation takes place in sight.

Another advantage is that the batches of aggregate can be automatically measured by means of an adjustable scraper, which also measures and spreads the proper amount of cement over the face of the dry aggregate.

A revolving frame, which has exterior and interior sides, between which the material is mixed, runs on a ball-bearing cast steel base, and is driven by a pinion connected with a geared rim on the outer part of the under side. Through the centre of the machine is a perpendicular shaft, to which are hung angle iron frames; to these again ploughs are fixed. These ploughs are adjustable, and can be raised or lowered at will, and extend from the inner to the outer circle, by which means every part of the material is dealt with, and turned over.

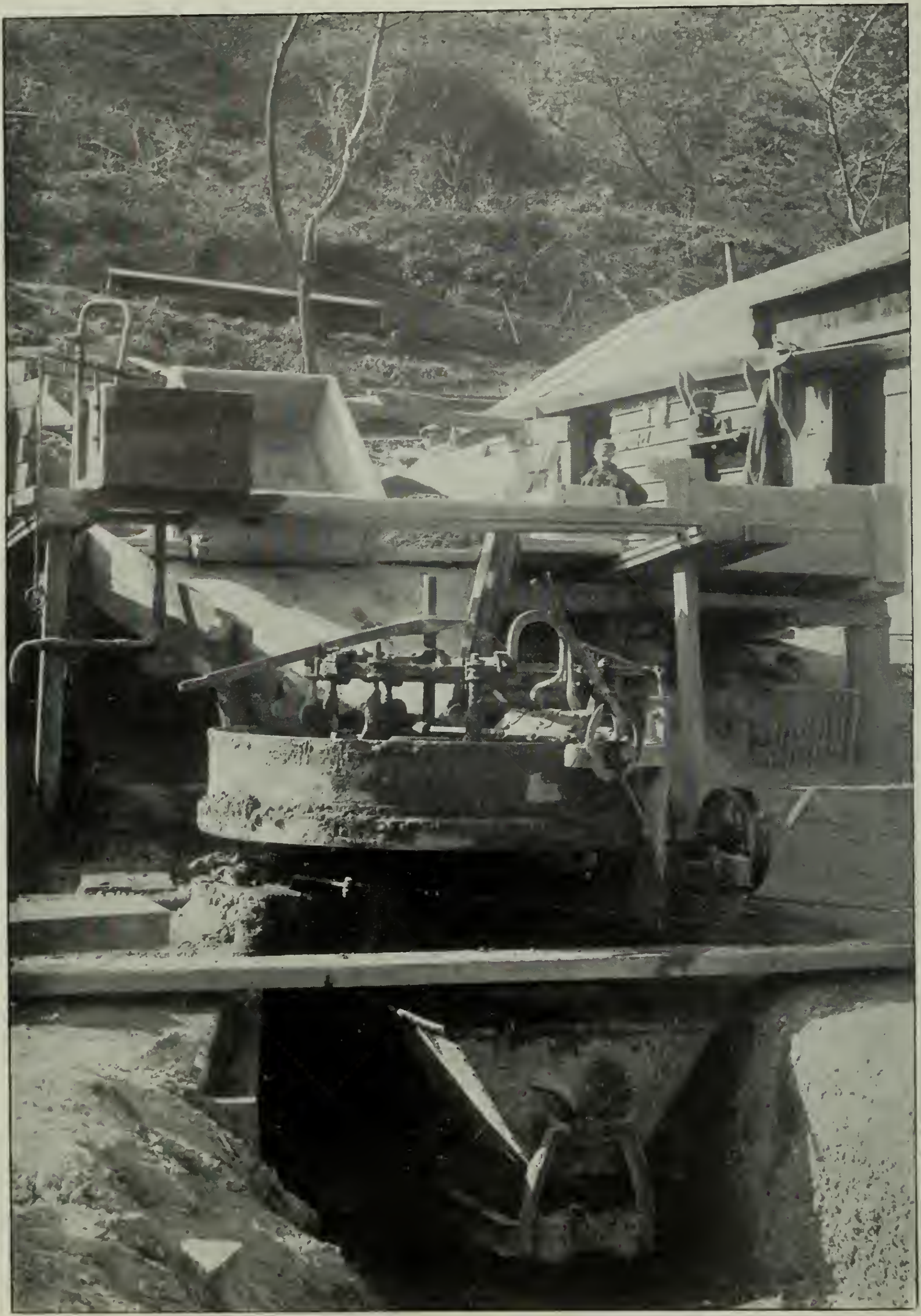


The "Pansy" Concrete Mixer.

These revolving ploughs are set at such tangents as to allow of thorough mixing in the dry state until the mixture is of even colour.

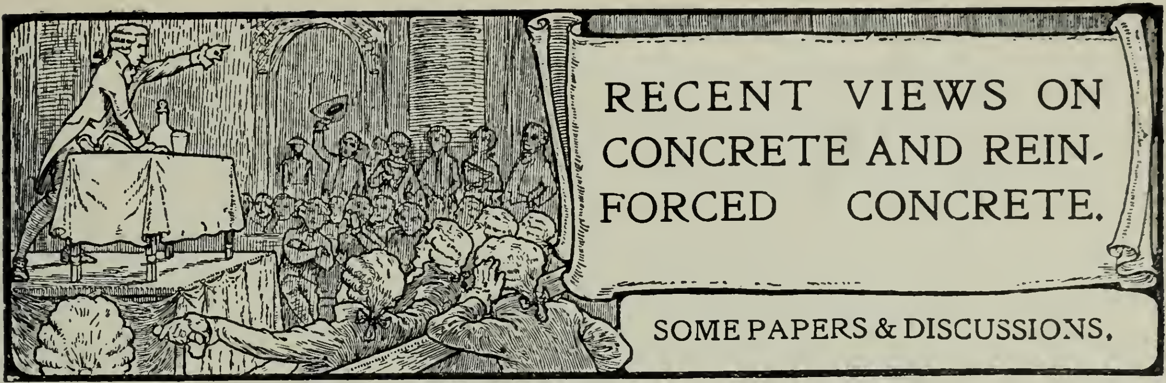
The pan revolves at the rate of 10 to 12 revolutions per minute, and as the ploughs are stationary, a thorough mixture is assured after a very short time. Although this pan revolves, the mixture can be discharged at one spot and just where wanted.

The mixer also cleans itself automatically, which is a feature worthy of notice, as a great saving of labour is thereby effected and the cleansing is much more effective than if done by hand.



"Pansy" Mixer at Work for the Reinforced Concrete Culvert at Kilton.

A general view of the machine is shown on page 297. Above will be found an illustration of one of these mixers at work for the reinforced concrete culvert at Kilton, for the North-Eastern Railway Co.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE SURVEYORS' INSTITUTION.

THE EVOLUTION OF FIRE-RESISTING CONSTRUCTION.

Paper by WILLIAM WOODWARD, F.R.I.B.A., F.S.I.

At the Ordinary General Meeting of the Surveyors' Institution, held on February 6th, 1911, *Mr. Leslie R. Vigers, President, in the chair, a paper was read by Mr. Wm. Woodward on "The Evolution of Fire-Resisting Construction," a summary of which we publish below.*

As early as 1835 Mr. George Godwin read a paper on the "Nature and Properties of Concrete," and on the architectural treatment of it. He showed how concrete had been used largely as a building material by all the principal civilised nations of antiquity ; how Alberti had described walls made of it, nearly in the same way as is done now, by moulding it between boards ; how Pliny had described cisterns made of it ; and how many of our principal buildings, including St. Paul's and Westminster Abbey, stand upon concrete foundations dating from Roman and Saxon times.

Evolution was sometimes slow in its working, but the evolution of fire-resisting construction in our buildings could not be said to be of prolonged growth. It was the knowledge and appreciation of the uses and value of concrete, as much as of the uses and value of steel, which gave rise to that impetus in their combined uses which has culminated in what we know as ferro, or reinforced concrete construction.

In 1854 architects were keenly discussing the construction of concrete floors, roofs, and walls, and their experiments led, no doubt, to a liking for the material as being fire-resisting and as one which could carry very large unsupported areas, and which was also cheap. There seems to have been at that time some difference of opinion as to the embedding of iron in the concrete, and as to its employment as a finished material in architectural decoration ; but there does not appear to have been any difference of opinion on the fact that concrete as a constructive material, whether with or without iron reinforcement, depends to a very large extent indeed upon the care with which it is mixed, and that no supervision can be too great to ensure strict compliance with this absolute condition.

Many years before 1854 Fox & Barrett's fire-resisting floors, and the various kinds of similar floors as regards fire, were in vogue, and such firms as Homan & Rodgers and Dennett & Ingle were paying great attention to this important subject of fire-resisting construction, and French architects and engineers especially were devoting their labours to the same end, and although the French methods differed from ours in detail, much the same ideas prevailed, except that the French construction was always much lighter than ours—they took greater risks, and yet there does not appear to be a case of failure in Paris due to collapse of a floor by reason of insufficient strength per foot superficial.

Early Papers on Concrete.—Fifty years ago comparatively very little was known of concrete for constructional purposes, but architects were even at that period beginning to test and to study this form of construction. He had little doubt that they should some day discover that the Egyptians knew all about reinforced concrete. and that the tomb of a departed Pharaoh owed its preservation to a mixture of iron and concrete. To prove that fifty years ago architects began to seriously consider concrete construction, he found that Mr. T. H. Lewis, on December 14th, 1857, read a paper at the Royal Institute of British Architects on some experiments upon concrete. Those experiments were directed to the suggested sensible loss in bulk of the ballast independently of that of the lime, and that the materials, after being mixed together, expand considerably. Mr. Lewis stated that this idea of loss of ballast was so prevalent that a respectable builder asked him to allow, in calculating the price of the concrete, one-seventh more ballast than the concrete cubed to. The general result of the experiments with lime concrete was " that the whole mass, made into concrete, occupied precisely the same space as the dry ballast—viz., 1 cu. yd., all the bulk of the lime and water (being about two-fifths of the ballast) being lost, but none of the ballast itself. The surface was carefully levelled and thin boards tacked over so as to ascertain if there were any expansion in the setting, but none could be perceived. The weight of the mass was 27 cwt."

Then on June 5th, 1871, two papers were read before the Royal Institute of British Architects, with Mr. Edward I'Anson (a Past-President of the Surveyors' Institution) in the chair. One paper was on the use of Portland cement concrete as a building material, by Mr. Thomas H. Wonnacott, in which he spoke of the " novelty of the material." The author was surprised to find Mr. Wonnacott stating he had not found that " a larger proportion of cement than 1 in 8 increases the strength of the concrete. On the contrary, it appeared to diminish it." For ordinary walling Mr. Wonnacott found 1 in 10 sufficiently strong, and that " in engineering works in Copenhagen 20 to 1 was the proportion used," and, further, that he was informed by an experimenter that " he had gradually lessened the proportion of cement to 1 in 24, and found it then make fairly strong work." This proportion would rather startle the engineer and architect of to-day, and he was surprised to find Mr. Wonnacott saying that in such a case the " conditions must have been exceptionally favourable," and the " dispersion of the cement among the mass perfect."

The second paper above referred to was read by Mr. A. W. Blomfield on " Concrete Building." This paper was confined to the consideration of concrete in walls constructed *in situ*, by filling concrete into cases or moulds, made to shift to the various heights and positions as the work proceeds. This system had since been very largely adopted.

Mr. Edward I'Anson in summing up the papers made one or two useful remarks, which were quite as useful to-day. He was convinced that unless thorough dependence could be placed upon the honest and conscientious execution of the work by the contractor, concrete was a dangerous material to use, inasmuch as a small percentage of inferior material in Portland cement would cause the ruin of the entire work. Mr. I'Anson mentioned that the Metropolitan Board allowed concrete buildings to be used in London, but insisted upon a considerable amount of iron hoop bond, and would not allow concrete walls of less thickness than brickwork. So that at this date " reinforced concrete, in the shape of hoop iron bond and concrete, was adopted."

Paper read in 1876 on " Concrete as a Building Material."—In April, 1876, Sir Gilbert Scott, R.A., in the chair, a paper was read at the Royal Institute of British Architects, by Mr. A. Payne, on " Concrete as a Building Material," which dealt with it ornamentally for the fronts of buildings and avoiding ugliness. Mr. Payne observed that once iron was bedded and kept from the air,it was entirely protected from rust and oxidation. Mr. Payne laid it down as an axiom that concrete offers unusual facilities as a material for walls, etc., " from the readiness with which iron or other ties can be embedded in it in any direction to resist any thrust or tendency to separate in the structure." Mr Payne showed a design for a street façade in iron and concrete, and went so far, in his intense admiration for concrete, to advocate the panelling of the interior of an apartment and " do away for once with the everlasting wall paper," and he practically described reinforced concrete when he proposed to " use iron embedded in concrete for the purpose of giving tensile strength to prevent fractures caused by thrusts of arches, vaults, etc., instead of opposing them by buttresses as is done in brick or stone."

The above paper was followed by an interesting discussion. Mr. W. H. Lascelles referred to warehouses gutted by fire, where lintels consisting of concrete with pieces of iron, 3 in. by ¼ in., embedded in the centre, were not affected by the fire, although the sills and other parts were. The concrete was mixed in the proportion of 1 of cement to 6 of breeze.

Mr. P. Brannon was a great believer in iron and concrete, and he made window heads by bedding rods of angle iron and dispensing with any framing or bressummers. He had then put in concrete doors in St. Paul's Cathedral, under Mr. Penrose, "in order to render fireproof that portion of the dome to which the public have access." Mr. Drake, at the same meeting, was most earnest in his partiality for concrete in floors, roofs, and staircases, and he asserted that good Portland cement concrete, or good silenitic concrete, or good lias lime concrete, correctly treated, "will never either contract or expand in the smallest degree after having once set." Mr. J. Tall stated, at the same meeting, that slag from the blast furnaces was an excellent material, because it is easily crushed and furnished in the crushing a sharp grit. He did not approve of iron in concrete floors. His first attempt was with an upper floor 19 ft. by 13 ft. without any iron joists; his second attempt was with a drawing-room floor 40 ft. by 16 ft., and he contended that that floor was stronger without iron than it would be with it. The thickness of the floor was 11 in. reduced to 4½ in. in the middle, and he believed there was not a crack or blemish to be found in the whole. Major Seddon, Royal Engineer, also made some important remarks on concrete at that meeting. He was not so much afraid of the work being scamped, as of failures arising from the ignorance of the contractor or his workmen. He had a slab of concrete made 6 in. thick and 14 ft. 6 in. by 13 ft. 6 in. clear of the supports, which were 14-in. brick walls, and after twenty-one days' setting, eighty men marched on to it, who marked time at the quick and double, and then jumped upon it altogether, without having any effect whatever upon the concrete. The whole of the unsupported part of the slab was then loaded with bricks, until an evenly distributed load of 10½ tons was piled upon it, when it gave way suddenly. The major stated that no iron whatever had been used in any of the concrete floors designed by him.

The London County Council General Powers Act, 1909, now enables skeleton-framed structures to be erected, at the same time permitting the reduction in the thickness of external walls in force under the Act of 1894; and the anticipatory objections to the provisions of that Act have been modified, and it seems to work well and does not entail those delays and interferences which some members of the profession thought would be likely to arise.

Different Methods of Fire-Resisting Construction.—Before coming to the most modern of fire-resisting constructions—viz., "Reinforced Concrete"—Mr. Woodward proposed to say a few words on other methods. There was the plain and simple rolled iron or steel joists, some 3 ft. apart, filled in between with concrete or breeze and Portland cement, this demanded centering, and at times trouble was caused by the exudation of moisture just when it was not wanted. One of the early floors, which still holds its own, was "Dennett & Ingle's." The steel joists were from 4 ft. to 10 ft. apart, according to the particular form of construction, in some cases the concrete was with arched and in others with horizontal soffits; each method lent itself to joists on plates bearing on the concrete, to wood block flooring, and to soffits either plastered on the concrete direct, or with ceiling joists and lath and plaster in the usual way. The material was concrete composed of highly calcined gypsum and broken brick, or of Portland cement and an aggregate of broken brick and gravel. This method demanded temporary centering. Messrs. Dennett & Ingle instituted a series of experiments for the encasement of stancheons, columns, and to girders which proved to be most successful.

There were then the various forms of fire-resisting floors consisting of brick or tile arches between iron or steel joists; different forms of terra-cotta laid on the joists and carrying concrete, such as the Frazzi floor—all doing away with the necessity for centering. The terra-cotta of these patent floors was made so that it could easily and accurately be laid in lengths between the steel joists and the soffits plastered afterwards.

The evolution of fire-resisting construction in the form of reinforced concrete might be termed a revolution ; because not only was it used for floors and walls, but for piles and girders.

That too much care and attention cannot be given to any form of construction, or the employment of any material which would minimise, if not abolish, the risk from fire went without saying ; and it was this dread of fire in buildings which necessarily alarmed those upon whom responsibility fell in case of deaths or injury from fire. Recent occurrences in business premises make one tremble at the thought of fire. The London County Council had from time to time initiated legislation having for its object the relief of such risks, and they had by a recent Act permitted the use of steel-framed structures which would encourage their use and lead to filling in with fire-resisting material, and so gradually tend to lessen these too frequently recurring accidents.

Enormous strides had recently been made in the manufacture and use of reinforced concrete for all sorts of purposes besides building construction—viz., bridges, staircases, etc., and, personally, he placed considerable reliance upon those engineers and architects who had made the subject a study. It was said that "Prejudice vanishes when knowledge comes," and if he were, at the moment, prejudiced against the use of reinforced concrete it must be put down to ignorance, and to a conservatism which should be absent when dealing with inventions. Frenchmen might be said to have been the pioneers in this form of fire-resisting construction, but an English architect, Prof. C. N. Reilly, had just constructed a church, at Shacklewell, throughout practically of this material, and both in design and appearance, from the illustration seen, it did not present any feature of ugliness. He could sleep comparatively happily in a building where the walls and floors were of this material, but a little nervousness would creep over him if he knew that the piers or vertical points of support were of concrete with embedded steel, and that nervousness would be alarmingly increased if he knew that the girders, with a bearing of, say, 30 or 40 ft., were relied upon to prevent collapse. It would be no comfort to him to be told that provision had been made for ten times the load which could ever be put upon the floor. They all agreed that in the first place great reliance was placed upon the Portland cement used. It should not be too fresh, it should be most finely ground, and it should be laid out on a boarded floor and turned over for a few days before it was used. Was this always secured ? Then the proportion in which it was mixed with the aggregate was of moment. Was this always attended to ? Of course, in all concrete work great care was required, and strict supervision necessary ; but in the modern work the limits were being pushed a little too far. The specification and drawings might be perfect, but the safety of the structure depended upon the mixing of the concrete and the proper and regular embedding of the steel or iron work. Now this mixing was left, as a rule, to labourers, and although the specified quantity of steel and aggregate might be there, if more of the Portland cement found its way into one part than should be, and less therefore in another part, he would certainly get nervous if a moving load with consequent vibration were brought to bear on the girder. It was also not clear as to the effect of the concrete on the steel or iron reinforcement.

Then as to expansion and contraction. Some authorities said there was none in reinforced concrete, but whether that be so or not, was expansion or contraction equal ? He meant did the concrete go with the steel, and the steel with the concrete, or did each go its own way ? If they did go their own way, then risk was at once present. Then did the steel or iron oxidise ? They were told they did not, but he did not know, and supposed they must wait and see. Without wishing in any way to place his views in opposition to those distinguished architects and engineers who were so freely using this reinforced concrete, he wished to make this paper perhaps a little useful by concluding with a few words of caution which might be acceptable.

First they must see that the best English Portland cement was specified, and then see that they got it. Let Belgium and Germany keep their Portland cement for themselves. Then see that the Portland cement was not used too fresh, and that it was turned out of the sacks on to a boarded floor for, say, three days, and turned over two or three times in the interval.

The aggregate must then be determined. They must avoid burnt ballast, but not well and evenly broken brick mixed with stone ballast, or breeze, quite free from particles of coal. Then they must not mind spending a little money on reliable clerks of works. A hundred pounds or so in salaries to such men, simply to supervise the mixing of the materials and the proper disposition of the reinforcement would probably save many thousands of pounds, and many lives.

The evolution of fire-resisting material apparently knew no bounds ; it had at the moment culminated in reinforced concrete put now to all sorts of uses. He was only concerned in *buildings*, and as regards these buildings, he should be sorry anything he said there would lead to any diminution of the use of reinforced concrete. He would say one final word to *architects* (he left engineers to take care of themselves) : "Do not tremble at your floors and roofs ; be very confident about your walls ; be a little over-careful with your piers or other vertical supports ; but, be over, and doubly, and trebly anxious about your *girders*."

DISCUSSION.

Sir Henry Tanner, I.S.O., F.R.I.B.A., in proposing a vote of thanks to Mr. Woodward, complimented him upon the exhaustive and able nature of his paper, and went on to say that the improvement in fire-resisting construction synchronised with the improvements in Portland cement and steel. It was only in recent years that Portland cement had attained to its present excellence, so that they could rely upon it now far more than formerly, and although Mr. Woodward had suggested that it should be spread out and aerated, yet he thought that practice was now practically abandoned. They did not do so in connection with the Post Office, simply using the cement out of the bags, but he impressed upon them the necessity of using only the best English cement. Some time ago the British Fire Prevention Committee made a great number of experiments with a view to testing concrete floors, and the result of those experiments seemed to show that breeze was as good as any, and better than most, of the mixing used. It was better than granite, Thames ballast, and a long way better than limestone. He was not enamoured of terra-cotta tubes in connection with fireproof construction, and did not think they showed up very well. He agreed that careful supervision was absolutely necessary, especially in construction with reinforced concrete, and especially so with regard to the workmen. On the subject of rust, Sir Henry said steel was not affected by good cement concrete.

Mr. Henry Northcroft, in the course of his remarks, said that reinforced concrete was capable of carrying extraordinary weights in extraordinary positions, and that, he thought, was the secret of its success rather than its fire-resisting qualities. In using coke breeze the greatest care should be exercised to see that it did not contain coal or anything of that kind. or it would prove very dangerous indeed.

Mr. E. B. I'Anson supported the vote of thanks, and referred to the great interest his late father took in this subject as far back as 1854, constructing about that time a fireproof house at Clapham. which had stood the test of time very well, though fortunately it had not been put to the test of fire, Another early building in which they used concrete with hoop-iron bonds was a warehouse in Guilford Street, and some twenty years ago, when they built the Commercial Sale Room, they built the stairs, landings, and some of the floors of concrete, reinforced with suitable wire netting, and this had also been most satisfactory. One of the advantages of reinforced concrete was that they could get such tremendous spans without support, and he knew of no place where this could be seen to greater advantage than at the Post Office. He was surprised at the comparative thinness of the walls and the enormous weights they supported. With regard to architectural effect in dealing with such buildings, he admitted that the problem presented difficulties, but stated that in the case of a small residence in the country he had overcome this by utilising rough-cast, though this would not do for larger buildings in large cities or London.

Mr. H. Phillips Fletcher.—He agreed with Mr. Woodward as to the care necessary in mixing, remarking that, in his humble opinion, the mixing, if not nine-tenths, was at any rate seven-tenths. of all the trouble that resulted to reinforced concrete structures. For some months past he had been carrying out experiments for some of the City companies with regard to cement, and it was extraordinary the differences found between various samples of British Portland cement. In some cases it was as much as 50 per cent., and his brother and himself always insisted upon having an analysis of each truck as some safeguard in this respect. With regard to rusting, that was entirely, to his mind, a question of how the concrete was put in. Special care should be taken at the junction of columns and beams, and no steel should come within less than 1½ in. of the outside of the concrete. Experiments had shown that concrete made with broken stones and granite was 25 per cent. stronger than that made with gravel, and, as showing the possibilities of concrete with regard to the span, etc., he mentioned that Mr. West had designed and built a bridge of reinforced concrete with a span of 150 ft.

Mr. F. Huddlestcne, M.Inst.C.E.—They would not find that there was any rust if steel was surrounded by concrete made from good Portland cement. There was some chemical action, in the case of reinforced concrete with the cement of proper strength, which prevented rusting.

Mr. Woodward, in reply, said his only desire in reading the paper was to invite a discussion which might make the public more acquainted than they were at the present moment with this important invention, if he might so regard reinforced concrete. A notable example in London was the magnificent building erected from the designs of Sir Henry Tanner for the Post Office. He had known Sir Henry for some thirty or forty years, and no more careful man than he existed in the profession of architect, and whatever doubts he (Mr. Woodward) might have expressed in that paper he put them down for himself and congratulated all those men who had had the courage to employ this material, which had had such a marvellous effect in the construction of buildings, particularly in connection with those large unsupported areas which could not be obtained by any other means.

THE INSTITUTION OF MINING AND METALLURGY.

SHAFT SINKING AGAINST WATER IN FISSURED GROUND BY CEMENT INJECTION.

Paper by MR. A. L. SHRAGER.

The following is an extract of a paper recently read by Mr. Shrager before the Institution of Mining and Metallurgy.

THIS process is now replacing to some extent the Poetsch freezing process for the sinking of shafts in water-bearing ground. It was developed in the chalky formation of the Pas-de-Calais coalfield, but is equally suited for any fissured water-bearing rocks, although not for soft-running ground such as quicksand.

The Principle.—The principle is as follows : A number of boreholes of suitable dimensions are sunk at equal intervals in the form of a ring surrounding the proposed site of a shaft. Cement and water, injected through these boreholes by means of a force-pump, find their way into all the cavities and crevices of the ground surrounding each hole, in which the cement sets. As the cement from one hole penetrates the rocks surrounding it, that coming from the adjoining hole is encountered and a cemented, watertight wall is formed round the proposed site of the shaft, and it is in this way that one is able to get rid of the water troubles that occur in the process of sinking.

The equipment for this process is small and inexpensive as compared with that required for making an ice wall by the Poetsch process, besides which, when once the cement has set, the work of the plant is finished, whilst with the Poetsch method the machinery has to be kept at work until the shaft has been sunk and lined, a considerable extra expense being thus incurred.

As a result of these savings the cost of sinking by the cement injection is only about one-third that of the Poetsch process.

Advantages.—Its practical advantage is that water is almost completely shut out, and the erection of a masonry lining, if necessary, is made more secure ; indeed, the solid wall of concrete makes the lining almost superfluous.

The danger to shaft sinkers is greatly lessened by the employment of this method, as they have not to cope with continual water troubles when sinking, and, in the event of repairs to shaft lining being necessary later, the existence of the permanent cement wall practically shuts out all water from the shaft, whereas with the Poetsch freezing process the water is only held back by the tubbing.

The particular shaft to which reference is now made was sunk at a coalfield in the Concession of Lens, in the Pas-de-Calais basin, where the process has proved so successful that all the most modern shafts have been sunk by this method.

Geology.—The section of the ground was as follows, in descending order :

	ft.	in.
Earth	16	3
Chalk	65	0
Chalk and flint	118	1
Sandstone	131	0
Grey marl	213	0
Blue marl	262	0

Deeper than this the strata were strong and practically impervious to water; thus the process only required to be taken down to 213 ft.

A preliminary pit was first dug to facilitate operations and to afford a fairly solid stratum for inserting injection pipes.

This pit was lined with masonry 2 ft. 3 in. thick to an inside diameter of 24 ft. 4 in., and six boreholes, evenly spaced around a circle having a radius of 14 ft. 3 in., were then bored and injected with cement in successive stages.

Each hole was bored with a Churn drill when encountering hard measures, but for soft, argillaceous strata rotary auger drills were used. The lining case at the head of each borehole was packed round with concrete in order to prevent leakage around the upper ends of the hole and to ensure the application of the full pressure of the pumps.

The lining case was made of steel 2 in. in thickness, with an inside diameter of 11·6 in. Its upper end had a cast-iron head or plug to which the necessary pipe connections were made.

An iron pipe fitted with a pressure gauge and stop cock entered the side of the casing just below the iron plug or head. During the washing of the hole which followed each drilling operation this pipe carried off the muddy water, but as soon as the water came clear the pipe was connected to the cement mixer, in order that any excess of cement injected might be returned to the mixer and utilised.

Boring.—For boring through the limestone, a heavy free-falling system of drilling was used, which permitted of more rapid boring and a quicker injection of cement than were obtainable by means of the lighter drills which were originally tried, but without good results.

Each application of these augers deepened the hole about 3 ft. 3 in., and the walls of the hole were then scraped by means of reamers, which removed any clay covering or other material that had been forced into the cavities and fissures, and which would otherwise prevent the cement from penetrating into the cracks and fissures.

The drill stem, which was formed of hollow steel tubes of 2½ in. internal diameter, was used for injecting the cement.

By this method between 10 and 13 ft. were bored and cemented per day of 13 hours.

Mixing of Cement and Water.—In order to ensure a perfect mixing of the cement and water, as well as to save in labour, mechanical mixers are now installed.

These each consist of a tub in which a shaft with paddles makes about 1 rev. per sec. The cement and water are thrown in at the top and the mixture run off to the pumps through suction pipes placed near the bottom of the tub, but above the suction valves of the pump.

From the bottom of the casing pipe, embedded in concrete, the strata were either injected with cement in successive stages of 16 ft. 5 in., at pressures varying according to the ground, or in some cases a borehole was driven to its full depth so as to cement round the entire length of the hole in one process.

If the injection was being done by stages, after the required depth had been bored and the hole thoroughly washed in each case before injection, a cup-shaped plug was lowered to the bottom of the hole for the purpose of preventing any cement from sinking downwards that would naturally solidify and hinder the boring of the next stage. This plug was raised after each injection, and not lowered until the next injection was required.

The injection pipe should be of comparatively small section, so as to compel a rapid circulation of the liquid cement in the pipe and round the bottom of the hole, whereby any tendency of the mortar to separate is overcome.

If at the surface the end of the pipe is connected to the pump by means of a strong rubber hose, permitting a certain amount of vibratory and sliding motion of the pipe, this also to some extent prevents accumulation of the cement in the pipe, that would tend to choke it.

After the injection pipe has been lowered almost to the bottom of the hole the head-gear or "plug" is bolted to it. Clear water is then put through the pump, the cock on the return pipe at the top of the casing under the plug being left open.

The Injection.—After a thorough washing of the hole, and when the return water is clear, the cock is shut and the pump drawn at full capacity, in order to drive any remaining *débris* as far back as possible into the fissures and cavities which are to be cemented.

This lasts about a half-hour, and then, without changing any conditions, cement is injected gradually to form about 5 per cent. of the weight of mixture.

After about one hour the quantity of cement is raised to 10 per cent. if no increase of pressure has been noticed in the hole. As the cement deposits in the fissures of the rock the pressure recorded by the gauge increases.

Finally, as the fissures become more thoroughly plugged with cement, in order to avoid too great a pressure and the stopping of the pump, the cock on the return is gradually opened and any excess of cement carried back to the mixer.

The operation is finished when it becomes necessary to keep the return pipe entirely open to maintain the working of the pumps.

The pump and pipes are then cleaned by running through them a current of water, after which the pipe in the hole is withdrawn and the hole left from 8 to 10 hours to allow the cement to set and solidify.

No cement is left in the hole after the washing, as all the cement that has been consumed has found its way into the surrounding ground.

When it is noticed that the pressure in the pipe has suddenly dropped, this being due to the dislodgment of a plug in a partially solidified cemented fissure or to the opening of a channel connecting with the surface, mortar containing 30 to 33 per cent. of cement is injected under low pressure. Another way of meeting this trouble is to line the hole down to some solid stratum with a casing pipe smaller than the upper one.

All six boreholes were injected in the same manner, and, after they had been taken to a depth of from 10 to 15 m. (32 to 49 ft.), sinking operations were started.

To give some idea of the amount of cement injected and the pressure required in different cases, I have taken No. 2 borehole for an example :

Depth.	Rock.	Cement Absorbed.	Cement Returned.	Pressure Per sq. in.
ft. in.		Sacks.	Sacks.	lb.
16 0	Earth	—	—	—
32 0	Crumbly chalk	277	7	71
49 0	,, ,, ...	463	20	14·2—142
65 0	,, ,, ...	482	30	42·6—183
81 0	Chalk and flints	429	30	48·4—128
97 6	,, ,, ...	332	44	42·6—170
114 0	,, ,, ...	236	40	42·6—7·1
130 0	,, ,, ...	339	60	42·6—185
146 0	,, ,, ...	74	—	85·2—121
260 0	Grey fuller's earth	—	—	—
	Total for 146 ft.	2,632	231	—

Consumption of Cement.

	Sacks.
The number of sacks used in the six different holes	7,052
The number brought to the surface in washing	1,104
The number absorbed in the holes and therefore utilised... ...	5,988

During the actual operation of injection the percentage of the total consumption of cement used effectively in the six different holes was 84 per cent., but, of course, the remaining 16 per cent. were subsequently utilised by being pumped back, and subsequently injected into other holes as they came to be bored.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

THE NEW INFIRMARY, NORWICH.

Owing to the increasing number of persons requiring indoor medical treatment, the provision existing at the workhouse infirmary had been found quite inadequate; accordingly, the Norwich Board of Guardians decided in 1908 that the building of a new infirmary was absolutely necessary. The new women's wing and an administrative block were opened in October last, and it is hoped in the near future to complete the new infirmary by the addition of the men's wing. The whole block of buildings when finished will accommodate 215 patients.

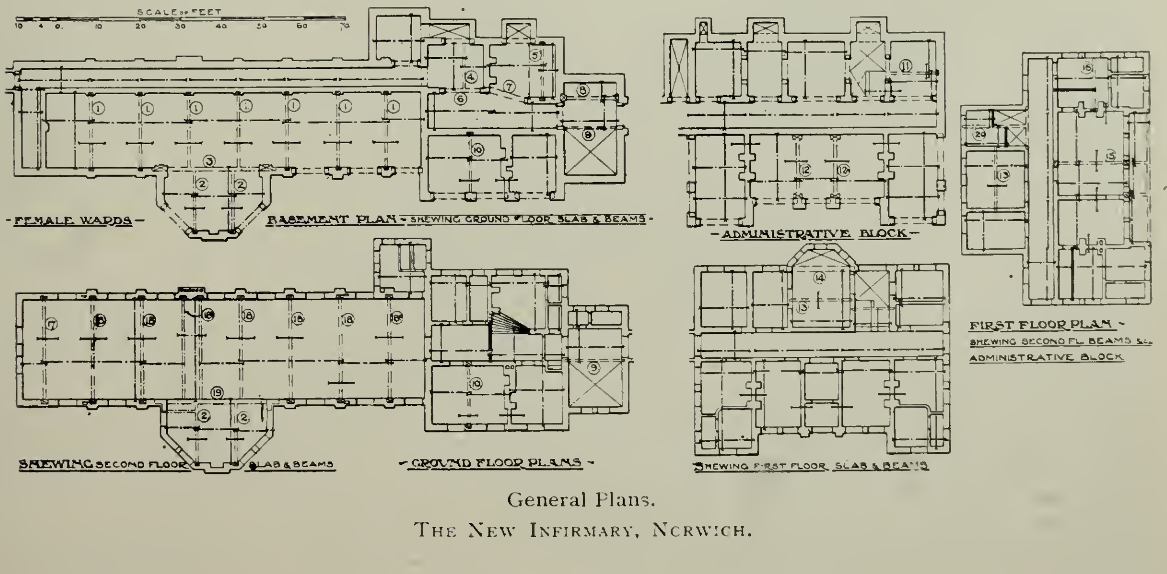
The new building is erected on vacant ground to the west of the old infirmary. The length of the pavilion is 96 ft. 6 in. by 24 ft. 3 in. wide, and it is connected to the administrative block by a well-lighted corridor, the three floors having the same plan. On each floor there is a large balcony, and spacious basements are provided below the ground floor of each building which serve for the distribution of hot water throughout the infirmary.

The whole of the floors, supporting beams, ceilings and staircases were built *in situ* with reinforced concrete on the "Wells" system. The external balconies are also in reinforced concrete, as well as the floors and roof of bridge connecting the pavilion with the administrative block.

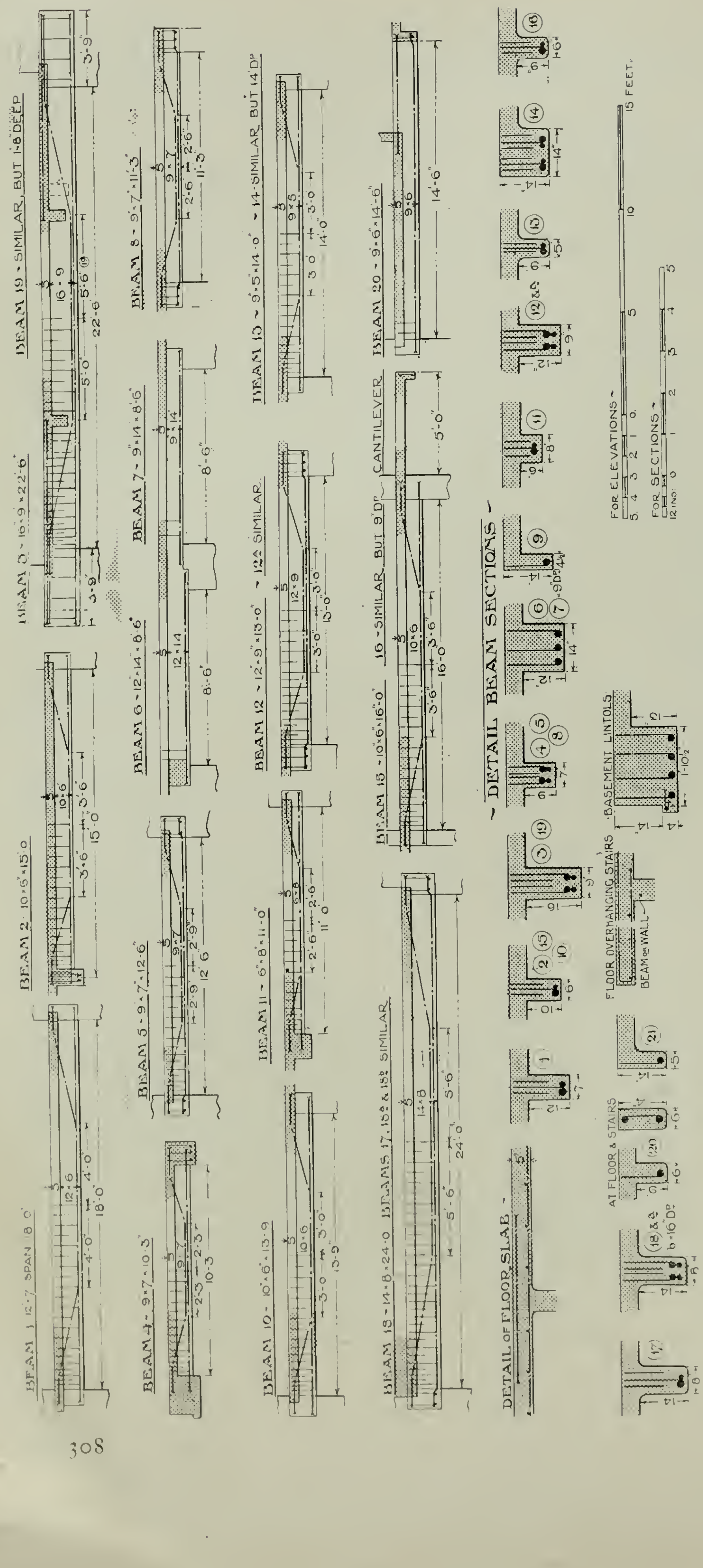
Details of the reinforced concrete floors and beams are shown in the drawings on this page, and on page 308. It will be seen from these that the main beams generally were 14 in. by 8 in., the span being 24 ft. 3 in. and placed at 12 ft. centres, all internal and salient angles being rounded.

The floors are 5 in. thick, and are generally finished with Doloment. Staircases throughout are of reinforced granolithic, the steps fitted with "Grano" safety tread.

In addition to the main infirmary, some additions were made to the nurses'


SCALE OF FEET
10 4 0 10 20 30 40 50 60 70
- FEMALE WARDS -
BASEMENT PLAN - SHEWING GROUND FLOOR SLAB & BEAMS -
- ADMINISTRATIVE BLOCK -
FIRST FLOOR PLAN -
SHEWING SECOND FL. BEAMS &c.
ADMINISTRATIVE BLOCK
SHEWING SECOND FLOOR SLAB & BEAMS
- GROUND FLOOR PLANS -
SHEWING FIRST FLOOR SLAB & BEAMS

General Plans.
The New Infirmary, Norwich.



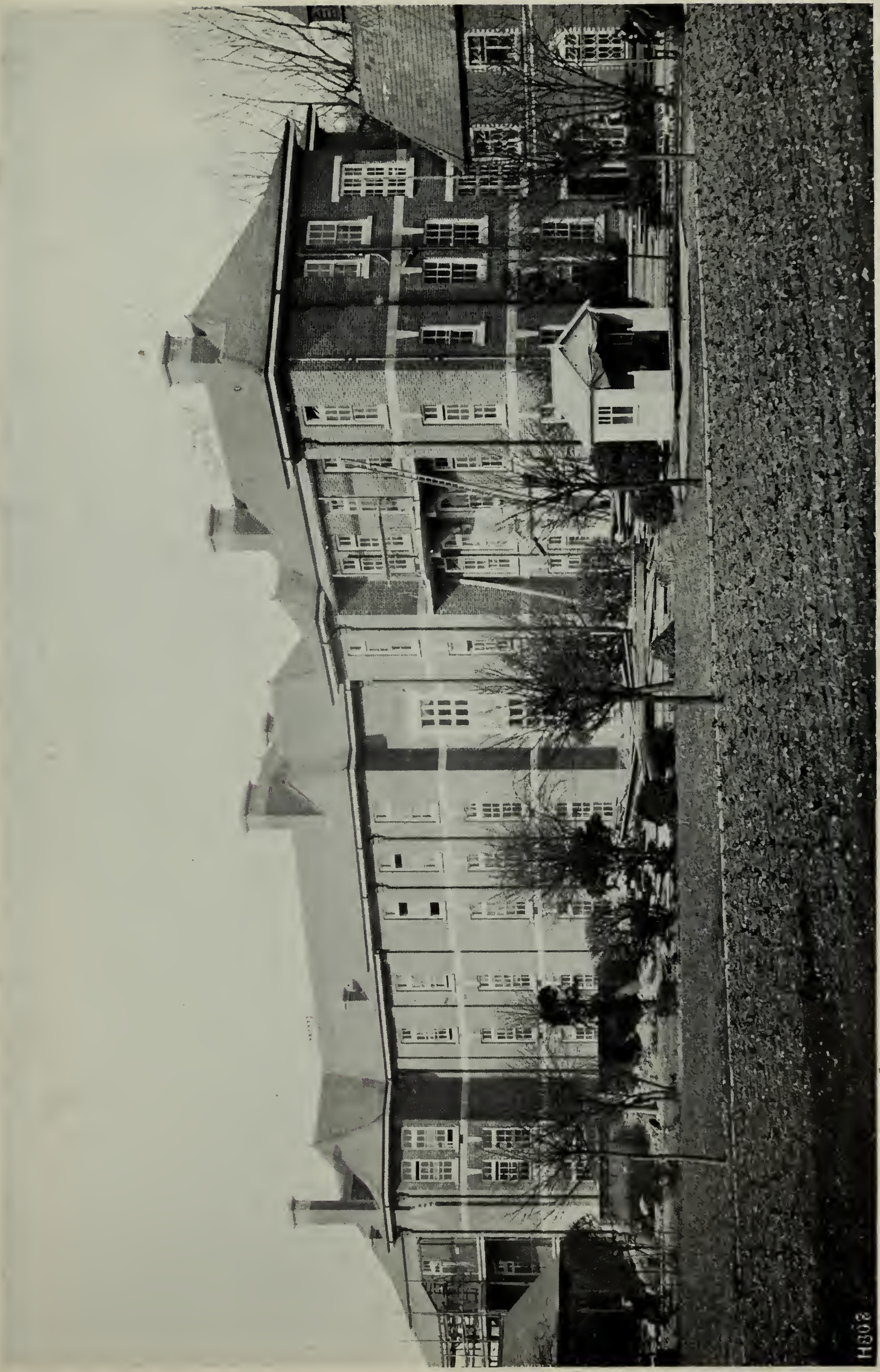
Details of beams.

The New Infirmary, Norwich.

home. Owing to the bad soil on which this portion of the work was carried out, the whole addition is carried by rectangular beams which, in turn, rest on concrete piers instead of jack arches as usually adopted. This also applies to a large portion of the main building.

The whole of the reinforced concrete, Granolithic, and mosaic work was carried out by Messrs. Bradford & Co., of Homerton, the architects being Messrs. Morgan & Buckingham, of Norwich.

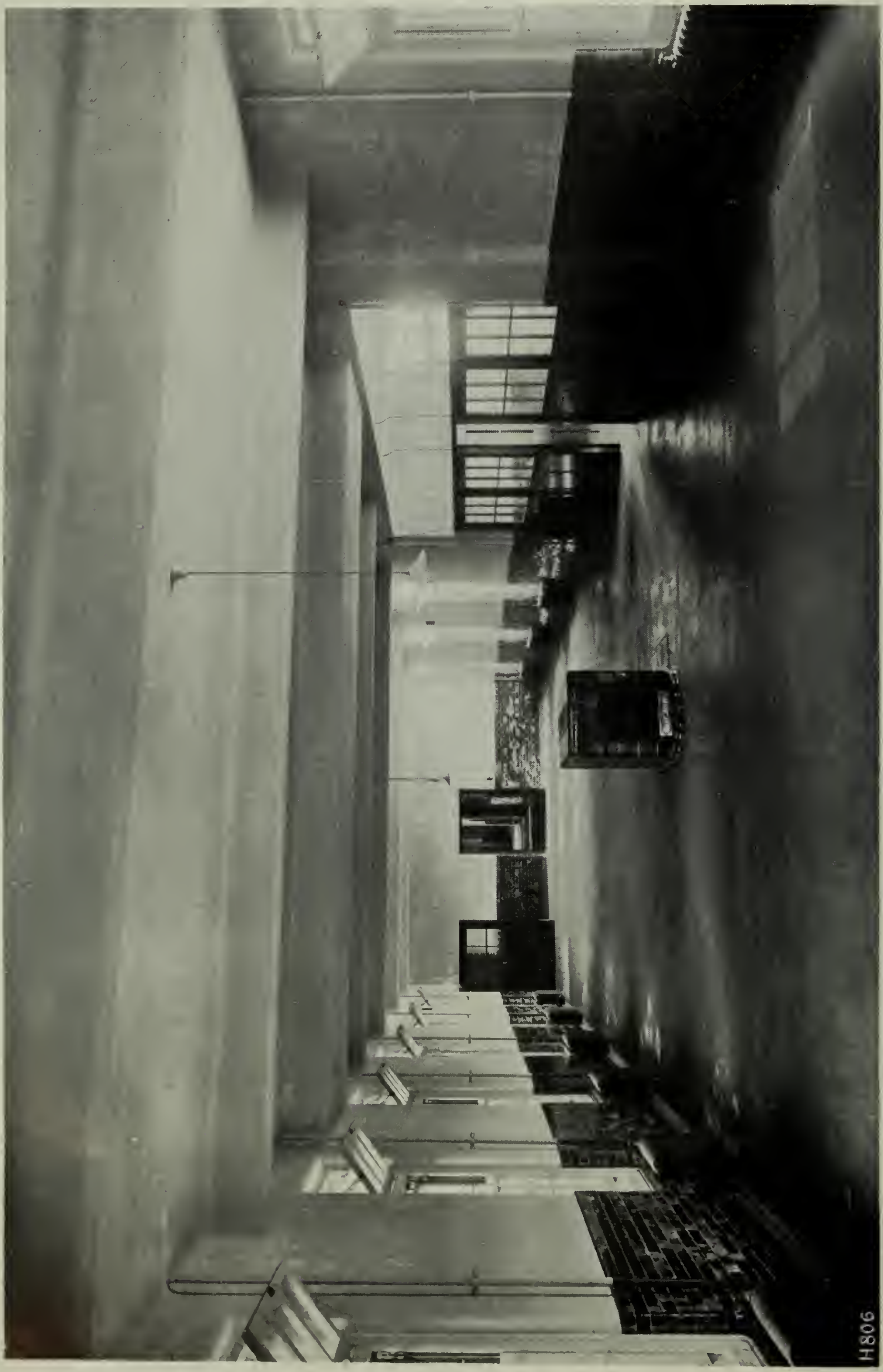
A good deal of reinforced concrete work has recently been carried out at Norwich by Messrs. Bradford, including the new Shire Hall with retaining wall at the foot of slope to Norwich Castle; also new bottling stores for Messrs. Whitbread, and a factory and offices for Messrs. Coleman & Co.



View of finished buildings
The New Infirmary, Norwich.

REINFORCED CONCRETE FLOOR IN RETORT HOUSE AT GUILDFORD GAS WORKS.

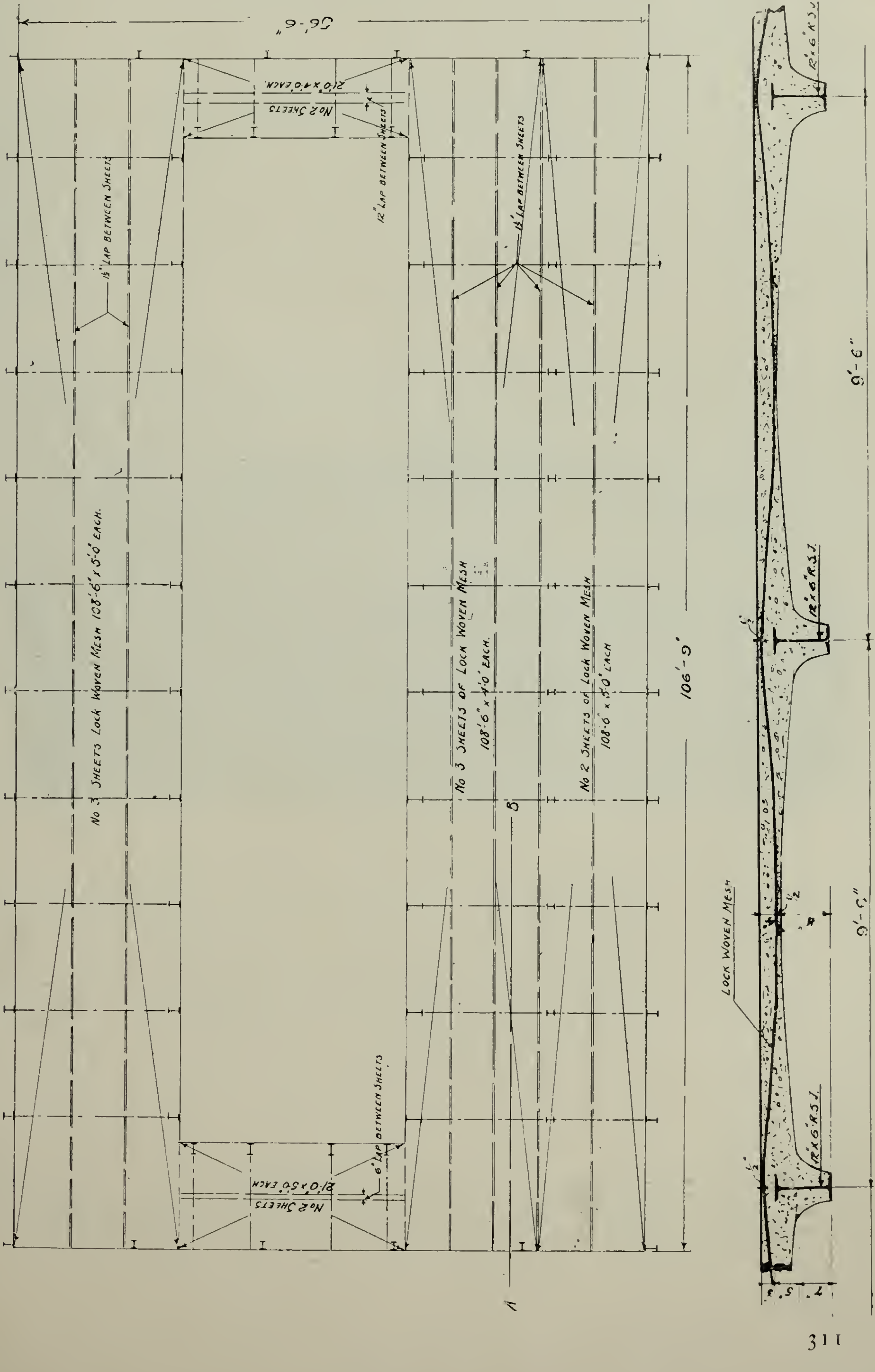
At the Guildford Gas Works a very interesting example of reinforced concrete has been carried out in the new retort house. The floor surrounding the retorts has been constructed on the Lock Woven Mesh System, the work being carried out by the



Interior view showing beams.
The New Infirmary, Norwich.

company's men in accordance with the method prescribed by the patentees, James H. Tozer & Son, of Westminster.

The building is 106 ft. 9 in. in length, divided up into bays averaging 9 ft. 6 in. span. The feature of the floor construction is the absolute continuity of the reinforcement. The lock woven mesh was supplied in rolls of 108 ft. 6 in. in length, and



Plan and Section.

PLAN AND SECTION OF FLOOR TO RETORT HOUSE.

unrolled side by side on the centering from one end of the building to the other, there being no joint or overlap of any kind in the whole length of the structure.

The position of the lock woven mesh is shown on the plan and cross section shown on page 311. It will be seen that great strength is obtained by the absolute continuity of reinforcement, and, therefore, jointless floor.

The whole of the work was carried out under the supervision of Mr. Penrith C. Cleasby, the gas company's engineer, who has expressed his entire satisfaction with this method of construction.

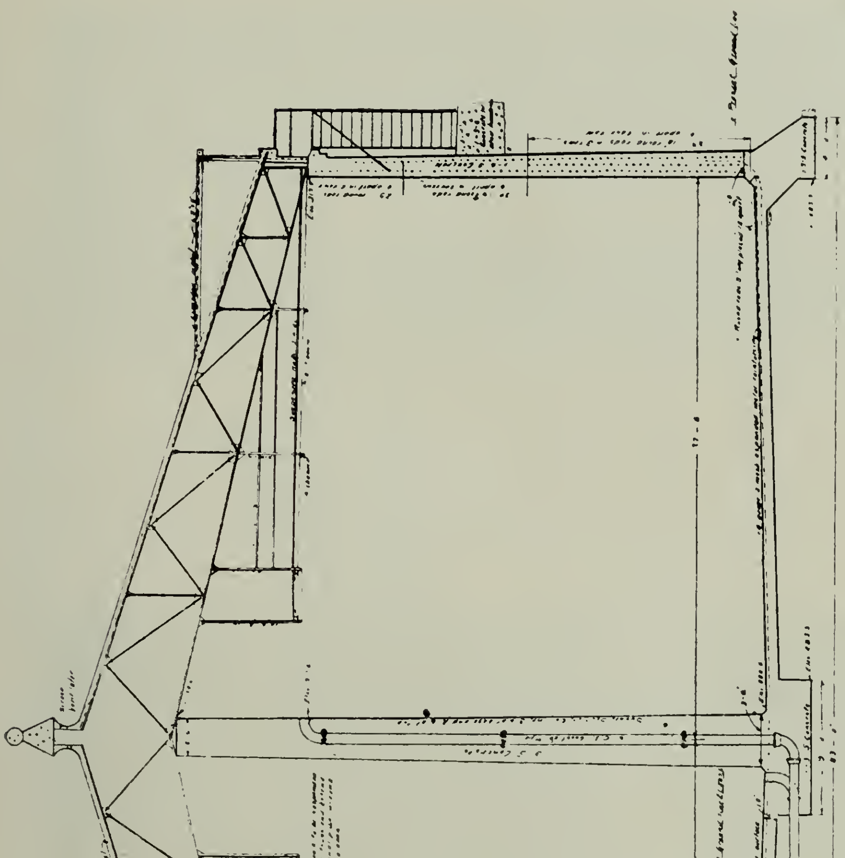
CIRCULAR REINFORCED CONCRETE WATER-TANK AT NEW ULM, MICH.

The City of New Ulm, Mich., has just completed a reinforced concrete reservoir of 1,000,000 gall. capacity, a cylindrical structure 75 ft. in diameter, with the walls 30 ft. high, and covered with a conical concrete roof. The ground on which the reservoir is built consists of hard clay, well drained by natural drainage, and upon this clay was spread a layer of stone with an average thickness of 12 in., the voids of which were filled with a wet, fine-grained concrete poured in. This formed the foundation for the floor, which is 10 in. thick, and reinforced near the surface with Expanded Metal of No. 16 gauge thickness and 3-in. mesh. The floor is bound to the walls by means of 1-in. round steel rods 8 ft. long, bent so as to extend 4 ft. into the floor and 4 ft. up into the walls. These were placed 12 in. apart throughout the circumference. The walls are 20 in. thick at the bottom, and taper to 15 in. at the top, with the batter on the outside. They are reinforced with 123 $1\frac{1}{8}$-in. and 40 1-in. round steel rods rolled to the required radius and placed horizontally, and by 20 upright supports made of steel angles with lacing bars, which served as supports for the horizontal rods during the time of construction, as well as vertical reinforcement in the walls. The horizontal reinforcement is sufficient to take all the stress without assuming tension in the concrete, or counting on the support of the earth embankment on the outside. The roof consists of a conical concrete slab 3 in. thick, and reinforced with No. 12 gauge, 3-in. mesh Expanded Metal, and is supported by eight trusses radiating to the wall from the centre pillar. The trusses are bound together with steel I-beams as purlins 5 ft. apart. The steel trusses are 6 ft. high from centre to centre of chord at the ends which rest on the centre pillar, and taper down to 3 ft. at the ends resting on the walls. Since it was of the utmost importance that the walls and the floor should be water-tight, special care was taken during the construction to grade the aggregate for the concrete. It has been found by

View of Finished Tank.

Circular Reinforced Concrete Water-Tank at New Ulm, Mich.

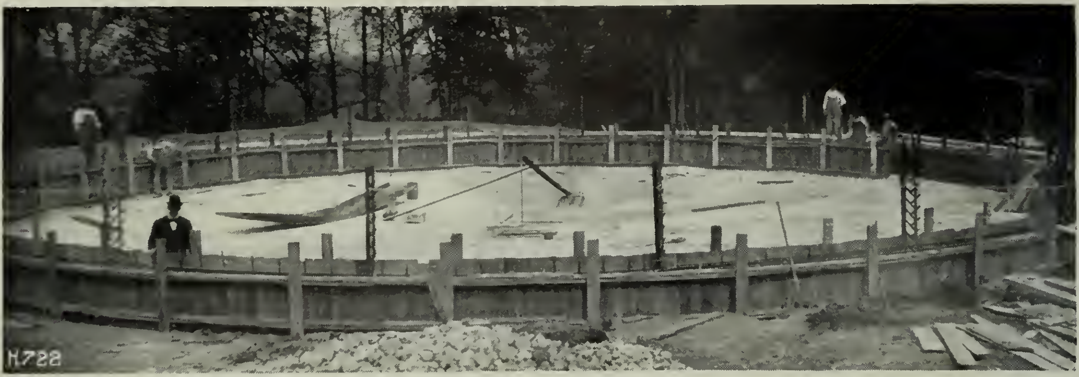
experiments that the densest concrete can be made when rounded pebbles, varying in size from about ¼ in. to about 2½ in., are used instead of broken stone, on account of the ease with which such pebbles will move about in a quaking mixture while it is being worked in place, and adjust their positions so as to form the least amount of voids. For this reason pebbles were screened from a gravel bank and used instead of crushed stone for the walls and upper part of the floor, and the sand used was a mixture of very coarse and ordinary fine sand. To reduce the permeability of the concrete to a minimum, 20 lb. of hydrated lime was used to every barrel of cement, and after the forms were removed the walls were brushed and cleaned with steel brushes, and two coats of cement plastering were applied on the inside. The mortar for the plastering consisted of 1 part cement, 2 parts sand, hydrated lime to the extent of 10 per cent., and Medusa waterproofing compound to the extent of 3 per cent. of the cement used. The proportion used for the concrete in the walls and the upper 4 in. of the floor was 1 : 2 : 4, and this proportion of concrete, together with the plastering, has apparently made the walls watertight, as no leakage has been noticed up to this time, except a small leak in the bottom shortly after the reservoir was filled, which was due to an



Section.

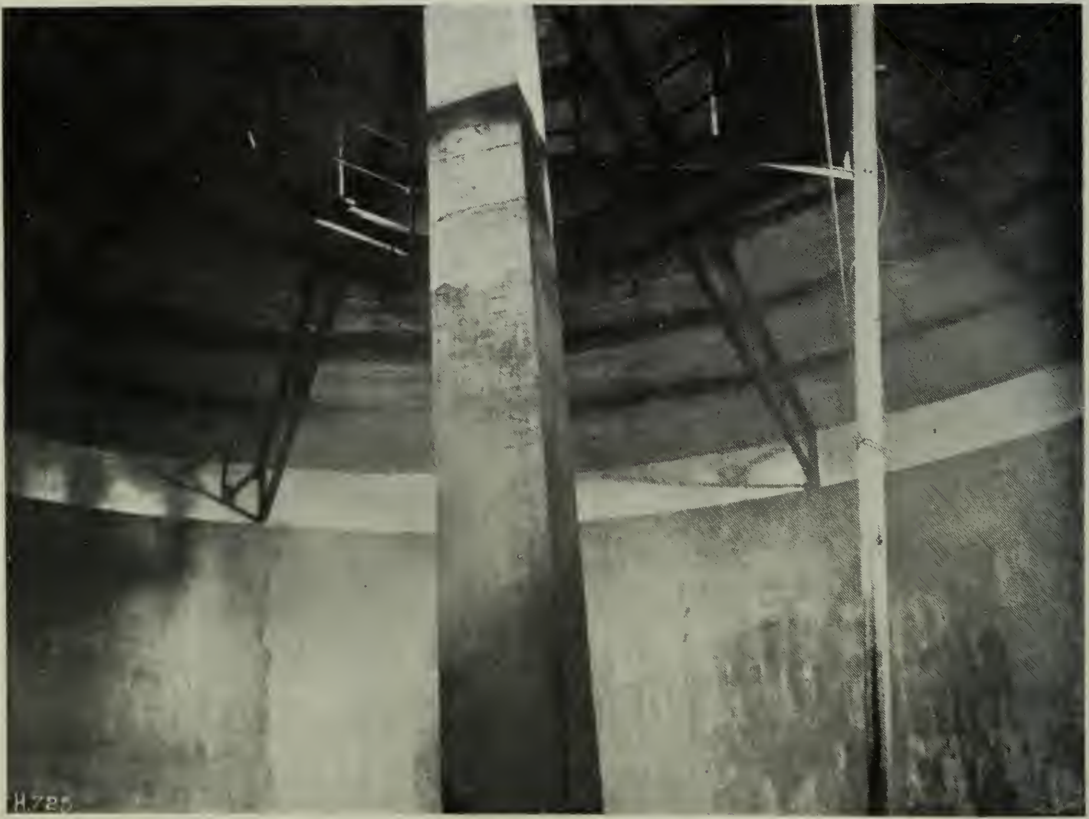
Circular Reinforced Concrete Water-Tank at New Ulm, Mich.

imperfect bond at one point between old and new concrete. This, however, did not cause serious trouble. The forms for the walls were made in sections about 12 ft. long by 2½ ft. high, and the inside and outside parts were bound together by means of ½-in. rods extending through the walls, which were removed after the concrete had acquired its initial set. The holes formed by the rods were afterwards filled with a strong cement mortar. Only one round of forms was used, as the contractor found that he could work most economically filling the forms in one day and removing them the next, and set them up for the pouring of concrete again on the third day. When it was necessary to build scaffolding, two days were taken to remove and set up the form and build scaffolds. The bond between old and new concrete was made by brushing the old concrete thoroughly clean and pouring on a neat cement grout just before pouring on the new concrete.



Showing floor supports for reinforcement and forms for walls.

Circular Reinforced Concrete Water-Tank at New Ulm, Mich.



Showing roof trusses after completion.

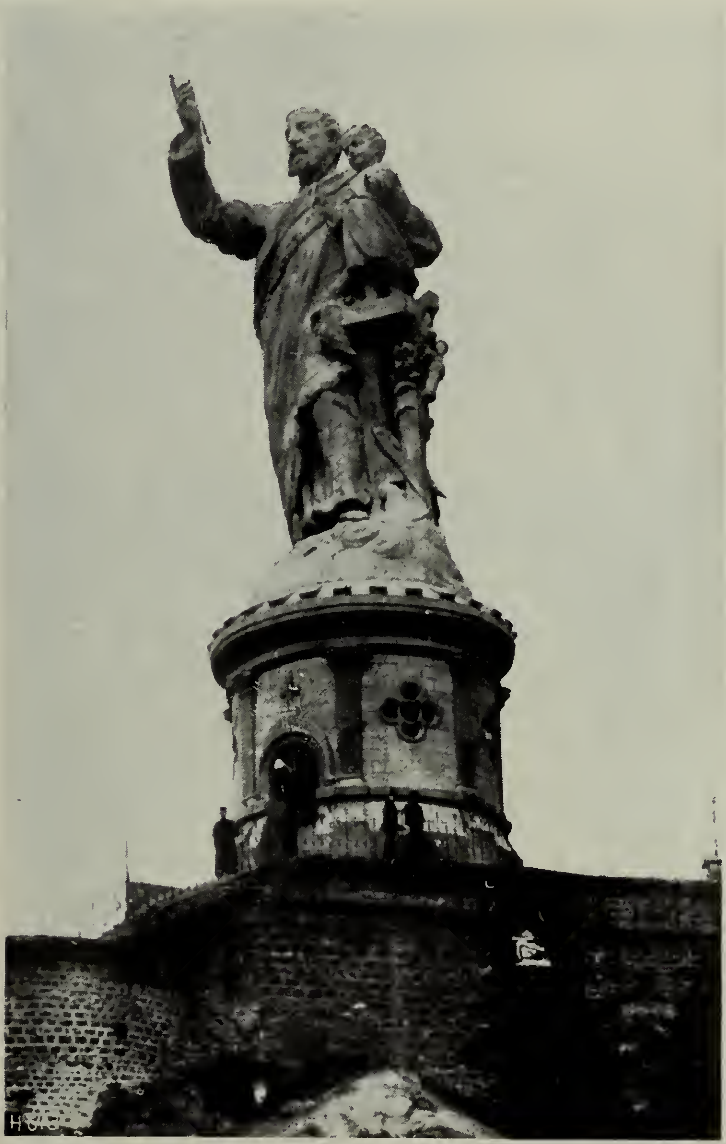
Circular Reinforced Concrete Water-Tank at New Ulm, Mich.

The above particulars are taken from a paper on this subject read by the engineer for the work, Mr. H. F. Blomquist, City Engineer, New Ulm, Mich.

NEW USES FOR CONCRETE AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

STATUE AT ESPALY (FRANCE) OF REINFORCED CONCRETE.



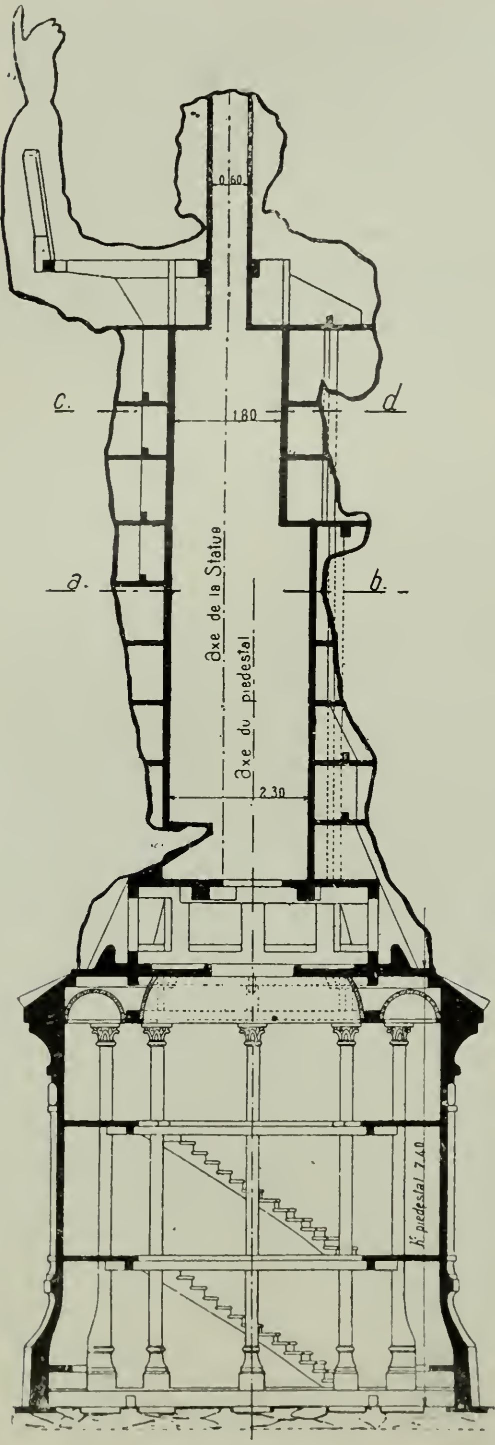
Reinforced Concrete Statue at Espaly (France).

The different uses to which reinforced concrete can be put is astonishing, and increases day by day. One of the latest is that of a monumental statue at Espaly, near the town of Puy, in France. In this place there is a *basaltic* rock at the summit of which a castle formerly stood. On the ruins of this castle a reinforced concrete statue has just been erected. The model of the statue is the work of the sculptor, M. Besquent.

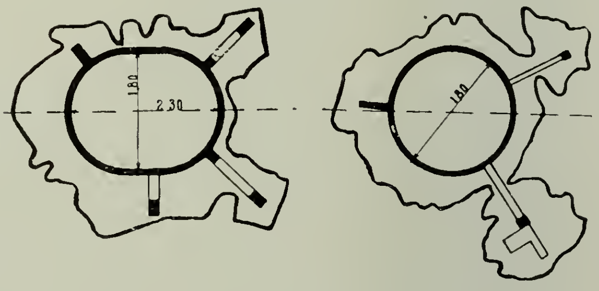
The work was done at two separate intervals. The pedestal was erected in 1906, and the figures were not commenced till 1908. The latter were to have been made of cast iron, but difficulties arose which led the Abbé Fontanille, who was having the statue erected, to have recourse to reinforced concrete, which had given such good results for the pedestal.

The pedestal, which was erected by the Hennebique concessionnaires in St. Etienne, Messrs. Chaussat & Tabard, takes the form of a tower divided into seven vertical panels separated by pilasters. Its height is 7·40 metres (24 ft. 4 in.), and its diameter 7·50 metres (24 ft. 8 in.). Inside, seven columns, each 20 cm. (8 in.) in diameter, are arranged concentrically and reach to the top, where they support a ring-shaped beam, which carries the upper platform. They also support two circular galleries at different levels reached by staircases. A central opening in the upper platform gives access to the interior of the statue if required.

The statue is 14·70 metres (48 ft. 6 in.) in height from the platform to the top of the head, making the total height of the monument 22·10 metres (72 ft. 9 in.). The weight of the statue alone is about 80 tons. The principle adopted in its construction is the erection of a reinforced concrete skeleton, rigidly fixed to the pedestal, and subsequently incased in a thin shell of reinforced concrete, the external surface of which is moulded to correspond exactly with the enlarged image of the original model.

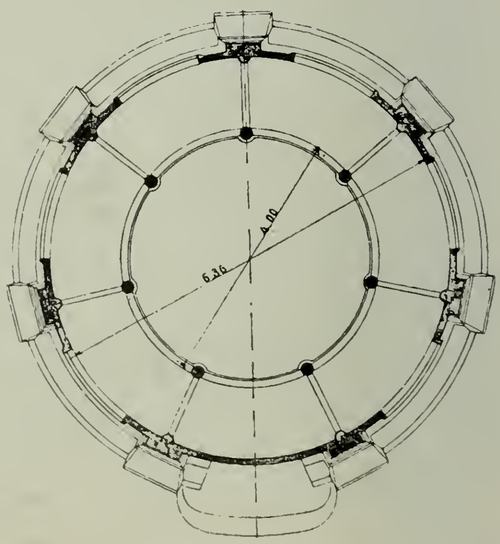


Vertical section.



Section a b.

Section c.d.



Sectional plan of the pedestal.

Reinforced Concrete Statue at Espaly (France).

The skeleton consists essentially of four parts :

1. A cylindrical base, concentric with the pedestal and resting directly on it ;
2. A vertical chimney of oval section, placed in the axis of the statue ;
3. A series of horizontal ribs connecting the chimney with the external shell ;
4. A special limb for the support of the right arm.

The base consists of a circular drum, stiffened by eight buttresses which connect it with the platform and assure its indeformability. A rigid floor with intersecting beams rests on this drum and bears the whole load of the statue. Above this is the chimney, oval in section up to the level of the carpenter's bench, then circular from this point to the upper platform. Above this level it is reduced to a tube, 16 cm.

(24 in.) in internal diameter, passing through the head. The upper portion of this tube is formed by a glazed frame.

The horizontal ribs, which are rigidly attached to the central chimney, are nine in number, and are intended to support the shell and to transfer its load to the walls of the chimney. In order to stiffen the whole, it was found necessary to introduce buttresses into the folds of the drapery, a break in the lower part of the chimney necessitating the carrying of a part of it by a cantilever. This difficult part of the work was also executed by Messrs. Chaussat & Tabard.

The shell is composed of a number of reinforced concrete sheets, united to one another and to the supporting ribs in such a way as to leave no visible junctions, so that the work has the appearance of having been carved from a gigantic block of stone. In order to obtain such a result, it was necessary to make a full-sized clay model of the statue, to make hollow moulds, transport the moulds to the working place, cast the cement, erect, fix, and unite the sheets ; and, lastly, to retouch the joints.

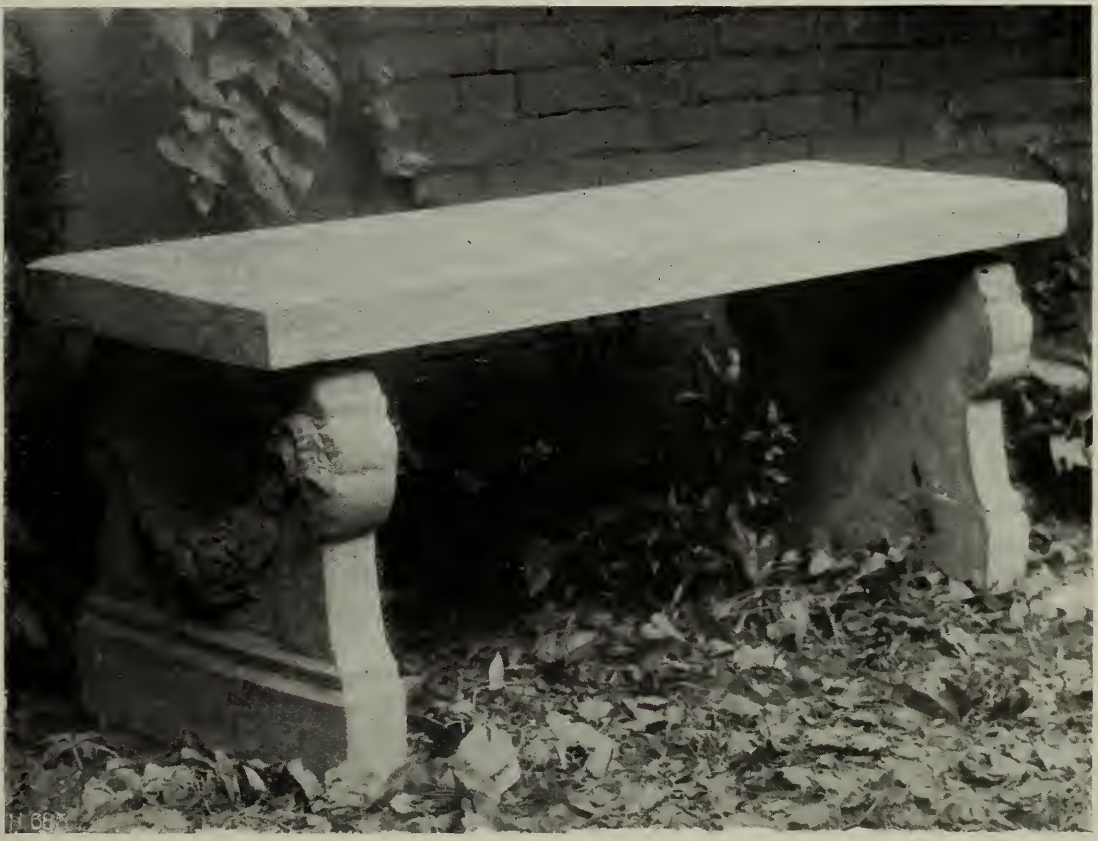
This part of the work was executed with mathematical precision under the direction of M. Debert, in spite of the many difficulties that presented themselves.

It may be hoped that this attempt, crowned as it has been with success, may open up a new prospect in reinforced concrete work, and cause it to enter definitely into the artistic domain, where it should find numerous applications.

We are indebted to our contemporary "Le Béton Armé," for the above particulars and illustrations.

CONCRETE GARDEN SEAT.

The Garden Seat illustrated below was made entirely of concrete by the students of the School of Industrial Art of the Pennsylvania Museum, and is a fine example of the suitability of concrete for out-door ornamental work.



Concrete Garden Seat.

ENQUIRY COLUMN.

The name and address of enquirers must always be given, not necessarily for publication.

The advice given in reply to enquiries is a matter of personal opinion, and although contributed in most cases by experts with special knowledge of the matter in question, it must not be considered in the same light as if obtained from a Consulting Engineer, Architect, or Solicitor, who should always be referred to in important cases, as our columns are not intended to do away with the services of the professional experts on constructional or legal matters.

Replies will be sent by post if the enquiries are marked "Answers by Post" on the outside. All other enquiries will be replied to in this column.—ED.

"GRANITE DUST."

G. G. (Indore, India), sends us the following enquiry :

> " I have noticed in a few specifications of concrete ' Granite Dust,' apparently as a substitute for sand. I find the greatest difficulty in obtaining good sand in my district, and would be glad to know by what process Granite Dust, suitable for use as a substitute for sand, is obtained, and if Trap Dust would do as well. I presume it is produced by a stone breaker. The important point appears to be whether stone for aggregate and dust for sand can be produced at the same operation."

If the makers of any machines suitable will communicate with us, and furnish reports of engineers who have used the plant, their letters will be forwarded to the enquirer.

EFFECT OF MINERAL OIL ON CONCRETE.

One of our subscribers wishes to obtain information as to the effect of turpentine or any other mineral oil on concrete tanks in which it is proposed to store it, and if it would be perfectly safe to do so. Can any of our readers give us results of experience as to this ?

FORMULA FOR A COLUMN OF CIRCULAR SECTION.

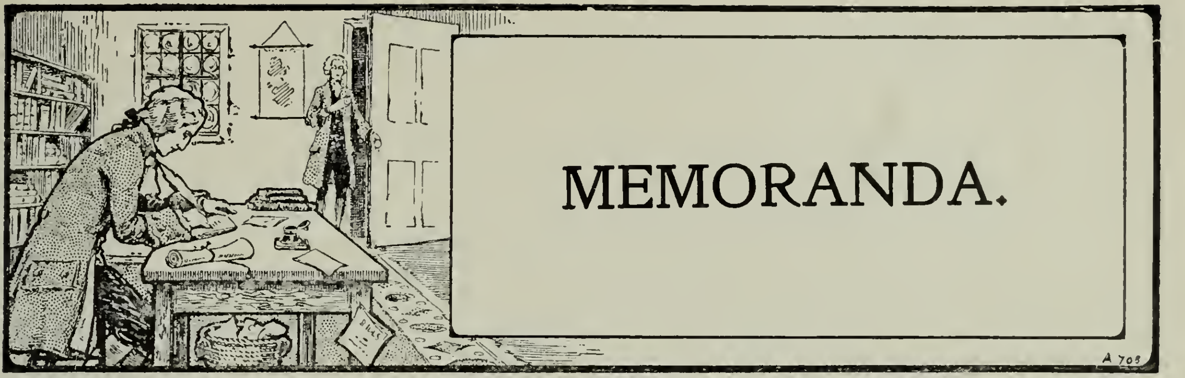
E. S. (Rangoon) writes :

> " In your article on the R.I.B.A. report, published in Vol. II. No. 3, you state the formula for a column of circular section with reinforcing bars arranged in a circle as—

$$Z = \tfrac{1}{8}A_c h + \tfrac{1}{16}(m-1)a\frac{h_t^2}{h}.$$

Should this not be $\frac{1}{4}$ (m—1) instead of $\frac{1}{16}$ (m—1) ? "

Reply.—The manner in which the foregoing is arrived at is given in Appendix III. of the report, the moment of inertia being divided by half the depth. The formula for the moment of inertia of the steel is that for a circle of negligible thickness.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Standardisation of Loads on Highway Bridges.—The Institution of Municipal Engineers have appointed their President and Messrs. Henry C. Adams and H. C. H. Shenton to represent them on the Joint Committee being formed by the Council and Science Standing Committee of the Concrete Institute to consider the loads that should be provided for in the design of highway bridges.

Bridge at Velindre.—The Aberavon Town Council have approved plans for the construction of a reinforced concrete bridge of three spans over the Avon at Velindre at an estimated cost of £1,466.

Bridge at Carr Hall.—It is proposed to construct a reinforced concrete bridge at a cost of about £3,000, towards which the Nelson Corporation have offered to contribute £1,000.

Bridge at Hull.—The city engineer has been instructed to obtain tenders for the reconstruction of the reinforced concrete chambers for the pumps, etc., and the temporary bridge, and has been authorised to carry out the planking and paving of the bridge, the masons' and bricklayers' work in attending upon the contractors, and other work with his own men at an estimated cost of £800.

Reinforced Concrete and Heating and Ventilating.—In an article in *Domestic Engineering* the advantages of reinforced concrete buildings, as regards heating and ventilation, are discussed. The writer of the article states that reinforced concrete buildings restrict the " air leakage " which takes place with other building materials. On the other hand, heat transmission through reinforced concrete walls is more rapid than through brick walls, partly owing to the better heat conductivity of the material, but principally owing to the decreased thickness of the walls. The article goes on to point out that to heat and ventilate a building on ideally hygienic lines has always been a matter of great expense, especially in cases of hospitals and other public institutions, and the engineer in charge of this work is greatly assisted, or the reverse, by the structural conditions of the building. It has been found that reinforced concrete is of great assistance to the heating and ventilating engineer, and as it is taken for granted that the public demand for reinforced concrete construction will certainly, if slowly, extend, it will be found that numerous advantages—though relatively small in themselves—will fall to the engineer through the adoption of this form of construction.

In the first place (the writer says) very careful and complete architectural consideration must be paid to the heating and ventilating scheme *pari passu* with the preparation of the plans. Flues and ducts cannot be concealed in thin reinforced concrete walls. Floors and walls must be planned for their admission beforehand, to avoid any considerable cutting through the hard concrete, with its vitally important arrangement of the reinforcement. In view of the fact that there will be no " roof space " in large concrete buildings as is required by some heating and ventilating schemes, definite architectural provision must be made for running the pipes. There will also occur at times a practical difficulty in conveying the vertical pipes and flues when, as in steel-frame buildings, division walls are not continued up and down from floor to floor. Then there will also be advantages in the direction of reducing the cost of the installation. Economy will be further increased by forming the ducts entirely of reinforced concrete—that is to say, doing away with all brickwork, making the ducts practically air-tight, and so minimising the heat losses in transit—a reduction which will be furthered by the formation of proper curves and angles which have not been easily possible in brickwork. Concrete ducts will also be cheaper to construct, and this fact should induce architects to view them with greater leniency than formerly. A further advantage to the engineer will be found in the method of laying the floors as the work proceeds, instead of waiting for the building frame to be first completed. These are typical instances of the changes involved in the adoption of reinforced concrete in the main buildings. In many minor respects further advantages, all tending both to economy and efficiency, will be found in the adoption of the new medium for the construction of such matters as chimney stacks, water storage tanks, "stumps," foundations for machinery, air inlet and outlet shafts, etc.

As reinforced concrete tends to more rapid construction than brickwork, and much more rapid than stonework, the consequent saving in first cost is allied to the many other advantages already recognised.

Tests of Soft Soap for Water-Proofing Concrete.—A large grain elevator and flour warehouse has recently been built on the bank of the River Donau, in Budapest, on ground subject to high floods. It was, therefore, imperative that the foundation, which consisted of a concrete mattress varying in thickness from 5½ ft. to 6½ ft., should be thoroughly waterproofed. Preparatory to this work, chemical analyses were made of the various waterproofing compounds in common use, and these indicated that the chief constituent and probable active waterproofing agent of most of them was potash or soft soap (Kaliseife). Upon the recommendation of Dr. Ing. Zielinski, the waterproofing layer was made 10 cm. (4 in.) thick, consisting of 9 cm. (3·54 in.) of concrete, in which stone of a maximum size of 1½ cm. (½ in.) was used, and of a 1 cm. layer of 1 : 3 mortar made with fine sand. The 9 cm. layer of concrete contained 800 lb. of cement per cubic meter, 1·3 cu. yd., and was tamped hard. The mortar layer was put down with a wood float. Instead of using pure water in mixing the concrete and the mortar, a solution of soft soap was used, the proportions being such that there were 6·6 lb. to 8·8 lb. of soap per cu. yd. of concrete and mortar.

Shortly after the completion of the work the foundation was subjected to a high head, due to a flood, and was found to be perfectly water-tight, though a similar foundation close by, which, however, had not been waterproofed, allowed the water to seep through.

In order to determine with some accuracy the action of the soap as a waterproofing agent, a test was made on a small concrete box. The box was 20 in. square and 11 in. deep, with bottom and sides 10 cm. (4 in.) thick, 9 cm. being of the waterproofed concrete above described, and 1 cm. of the waterproofed mortar. After hardening for 10 days the box was filled with water and placed out of doors for 28 days, where it was subject to rain, wind, and direct sunlight.

The box was then emptied and the mortar carefully removed in thin layers in order to learn to what extent the water had penetrated the bottom and sides. The top layer of 1 mm. (0·039 in.) was completely saturated, had a dark grey colour, and less density than normal 1 : 3 mortar should have. An examination of the structure of the mortar when magnified three times showed that the saturation of the layer was uniform. The next 1 mm. layer was somewhat damp, but thoroughly dense. Beneath this layer the mortar and concrete had the appearance of normal, air-hardened, dry concrete. When cut with a chisel it was found to be very hard.

A chisel cut 1½ cm. deep was then made in the bottom, and the box again filled with water and allowed to stand for 10 days. At the end of that period it was found that water had penetrated the concrete for a depth of 1 cm. around the cut, while the undisturbed layer of mortar on the remainder of the bottom and the sides of the box had been penetrated 2 mm. to 3 mm. (0·079 in. to 0·118 in.).

Dipl.-Ing. E. Schick, the author of the article from which these notes are taken, in attempting to explain the action of the soft soap, states that it cannot be attributed to any water repellent quality in the soap such as is possessed by fat and by mineral oils. The most likely explanation, he states, is that the free lime of the cement combines with the potash in the soap to form insoluble potassium oxide, which is of a sebaceous nature, and that this compound fills the pores.—*Engineering Record.*

The Treatment of Concrete Surfaces.—The Committee on Treatment of Concrete Surfaces of the National Association of Cement Users, of which Mr. L. C. Wason, of the Aberthaw Construction Co., is chairman, in their latest report recommended a treatment for all concrete surfaces which will give an even, light colour, and one extremely durable as proved by experience.

When the cement is green, rub off fins with No. 8 carborundum brick, wet the surface, and fill the voids with a mortar composed of 1 part cement to 2 parts fine sand. Then float the surface, leaving the least amount of material possible on the wall. Let it stand for any length of time. As a finish, clean down the wall surface, wet thoroughly, brush on a small amount of mortar, and immediately rub off with a No. 30 carborundum brick.—*Cement World.*

The Consistency of Concrete.—Although no definite specifications regarding the percentage of water can yet be prepared from the experiments on mixing concrete, conducted by the Committee on Treatment of Concrete Surfaces of the National Association of Cement Users, some interesting conclusions have been drawn. It has been found that the percentage of water added to concrete in mixing has a very marked effect upon its permeability, and that even slight variations from the proper consistency cause very much greater variations in permeability. It is, therefore, of great importance that concrete be mixed to the proper consistency to obtain the best results.

As to the best percentage of water, this varies with different cements and aggregates, and no rule can as yet be laid down; but with any given cement and aggregates, preliminary tests can readily be made to determine the proper amount of water to be used in mixing. This consistency can be gauged approximately by the eye. It is reached when such an amount of water is used that the water flushes to the surface freely when tamped, but not before tamping, and such that when it is thoroughly tamped the mass just barely quakes.—*Cement World.*

Washing Gravel.—A novel scheme for washing gravel has been in use at Bangor, where construction has been under way for some time on a new mechanical filtration plant. The concrete aggregate is delivered in piles near the work, and carried from them to the mixer in wheelbarrows. The gravel contains a certain amount of loam, and it was considered necessary to wash it before incorporating it in the concrete. To accomplish this holes were punched in the bottoms and sides of the wheelbarrows, converting them practically into sieves. Between the mixer and the storage piles a water pipe was connected up with a large perforated nozzle at its discharge end. Each wheelbarrow load of gravel on its way to the mixer was rolled under the nozzle and streams of water discharged upon it, the material being churned about with a spade to expose the lower part of the load to the cleansing action of the water. The water and the loam which it flushed out passed out through the perforations in the wheelbarrow, and the clean gravel was then carried to the mixer and used.—*The Engineer.*

Concrete Balusters in U.S.A.—The concrete balusters for the railing of the Jerome Avenue arch bridge, in the borough of the Branx, New York City, were at the beginning of the work cast in plaster moulds. These, however, gave satisfactory results only for three balusters, and then cracked or lost their sharp lines. Iron moulds were then tried, and have given satisfaction. One man, with the aid of a labourer part of the day, has been able to clean the forms, mix and pour six moulds, and finish the six balusters cast the previous day. The balusters are scrubbed to expose the aggregate, and to make the handling easier while scrubbing and prevent breakage are mounted vertically in a frame. A reinforcing rod projecting from top and bottom runs through the centre of each baluster, and the bottom of this rod drops into a socket on the work bench, while a ring holds the top. The baluster can thus be rotated as the scrubbing proceeds.—*The Engineer.*

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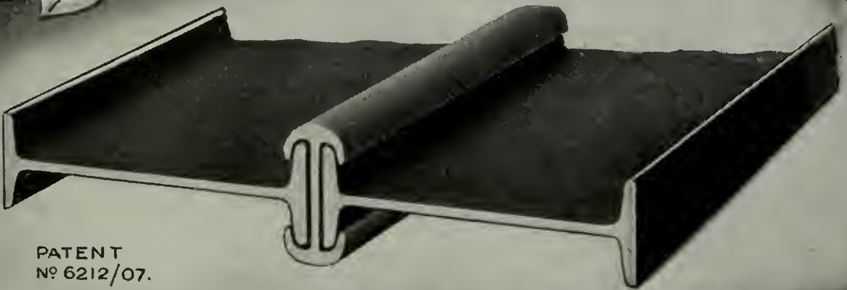

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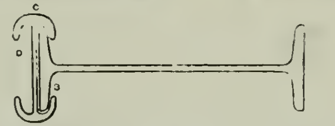

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15 in. × 5 in.	43 lbs.	39·5 lbs.	15·5 lbs.	·4 in.	·50 in.	·5 in.	·25 in.
12 in. × 6 in.	52·8 lbs.	39 lbs.	15·5 lbs.	·44 in.	·604 in.	·5 in.	·25 in.
10 in. × 5 in.	56·4 lbs.	35 lbs.	15·5 lbs.	·42 in.	·625 in.	·5 in.	·25 in.
8 in. × 5 in.	62·09 lbs.	28 lbs.	15·5 lbs.	·35 in.	·575 in.	·5 in.	·25 in.
6 in. × 5 in.	76·2 lbs.	25 lbs.	15·5 lbs.	·41 in.	·52 in.	·5 in.	·25 in.
5 in. × 5 in.	88·18 lbs.	24 lbs.	15·5 lbs.	·37 in.	·551 in.	·5 in.	·25 in.

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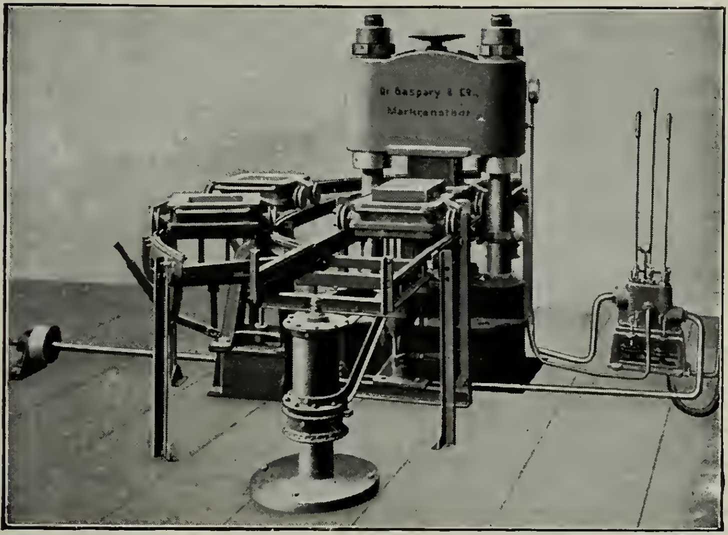
TRADE NOTICES, CATALOGUES, ETC.

Dr. Gaspary's Hydraulic Press with semi-circular guide rails for moulding boxes.—The reliability and easy manipulation of hydraulic presses have greatly contributed to their adoption for the manufacture of cement, terrazzo and granitoid plates. Whilst at the beginning only so-called slide table presses were used for the manufacture of smaller plates, and hydraulic presses with rotary pressing tables for making granitoid plates, the hydraulic press with semi-circular guide rails for moulding boxes has latterly been used with great success.

It has been placed on the market by Dr. Gaspary & Co., Markranstaedt, near Leipzig, and consists of a straight part passing between the upper and lower cross-beam, and of a pair of curved rails leading round the press in a semi-circle. The shunting of the moulding boxes from the straight to the curved part at both ends is effected by means of two rotary rails, which, by virtue of their gravity, form a permanent connection with the side at which the moulding boxes are. An accurate connection of the rotary parts to the fixed rails is ensured. The rotation of the turning rails is easy owing to the existence of ball bearings at the centres of rotation. So-called safety "snaps" stop the moulding boxes where required for the various stages of production. The moulding boxes themselves move easily, being also fitted with ball bearings.



Gaspary's Hydraulic Press.

The process of working is as follows: The moulding box which has been used is first cleaned and the oiled matrix inserted, or instead of oiling same a piece of paper is placed on it. The moulding box is then filled in the front and back layer for the plate, and the material partly shaken into place. This having been done, the moulding box, off which the surplus material has been cleanly swept, is pushed on to the turning rails, and on reaching the level part comes directly underneath the pressing head. The workman who is attending to the reversing device now moves the lever of same and so brings the pressure of the water up to the number of atmospheres desired, and which the manometer indicates. A second movement of the lever causes the water to run back, and thus releases the moulding box, which is then pulled over the hydraulic ejecting device. The ejecting of the first and the pressing of the following plate is effected simultaneously. The empty moulding box is then brought back to the spot where the matrices are inserted by the aid of the rotary rails, and the same procedure is repeated.

Practice has proved that, without in any way overtaxing the workmen, 750 granitoid plates, 350 mm. by 350 mm. (14 in. by 14 in.), can be manufactured in 10 hours. Two cement or terrazzo plates of 200 mm. by 200 mm. (8 in. by 8 in.) are manufactured at a time in a suitable moulding box, which brings the daily output of such plates to 1,500. Besides square plates, mitre-shaped plates, base cornice tiles, figured wall borders and others can be manufactured in corresponding moulding boxes.

Owing to the high pressure the press is of solid construction, and one of the special features is a pressing socket that can be lifted out, and which contains the pressing cylinder with the packings. The moulding boxes run securely on the rails.

and are provided with interchangeable steel coatings. The driving of the shaking device is effected mechanically by means of a cam shaft. Full information regarding this press can be obtained from the above-mentioned firm.

The Considère Construction Co., Ltd., of 5 Victoria Street, Westminster, inform us that their system of reinforced concrete has been selected for the new premises of the Royal Insurance Co. in Lombard Street, and that the retaining wall round the site and floor slabs in the building will be constructed to designs prepared by them.

Messrs. Hennebique, of Paris.—This firm have just published a pamphlet dealing with the special advantages of their method of reinforced concrete construction, and they lay special stress on its sound-proof qualities and the rapidity with which it can be erected. They compare it to steel structures, and show that these latter carry sound with far greater ease than reinforced concrete.

Concerning the rapidity in execution, they point out that reinforced concrete work can be put in hand almost immediately on receipt of an order, and one is in no way dependent on the usual workshop delays which occur when it is a question of a steel structure.

Numerous typical examples are quoted in support of this statement, notably among them the works executed at the Universal Exhibition of 1900—and also other important buildings in Paris and all over the world.

The pamphlet is well illustrated, and can be obtained on application to Messrs. Hennebique, 1 rue Danton, Paris.

The British Steel Piling Co. of Dock House, Billiter Street, E.C., have secured an order from Messrs. J. Mowlem & Co., Ltd., for their "Universal" Joist Steel Sheet Piling for the construction of the Embankment Wall for the London County Council from Victoria Gardens to Lambeth Bridge.

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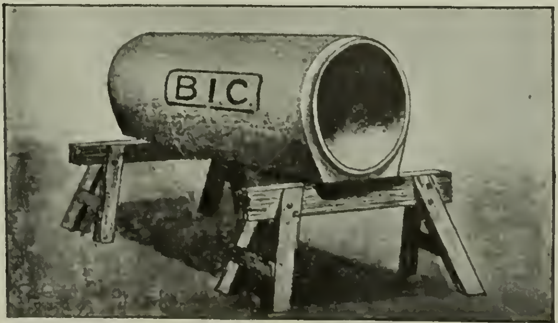

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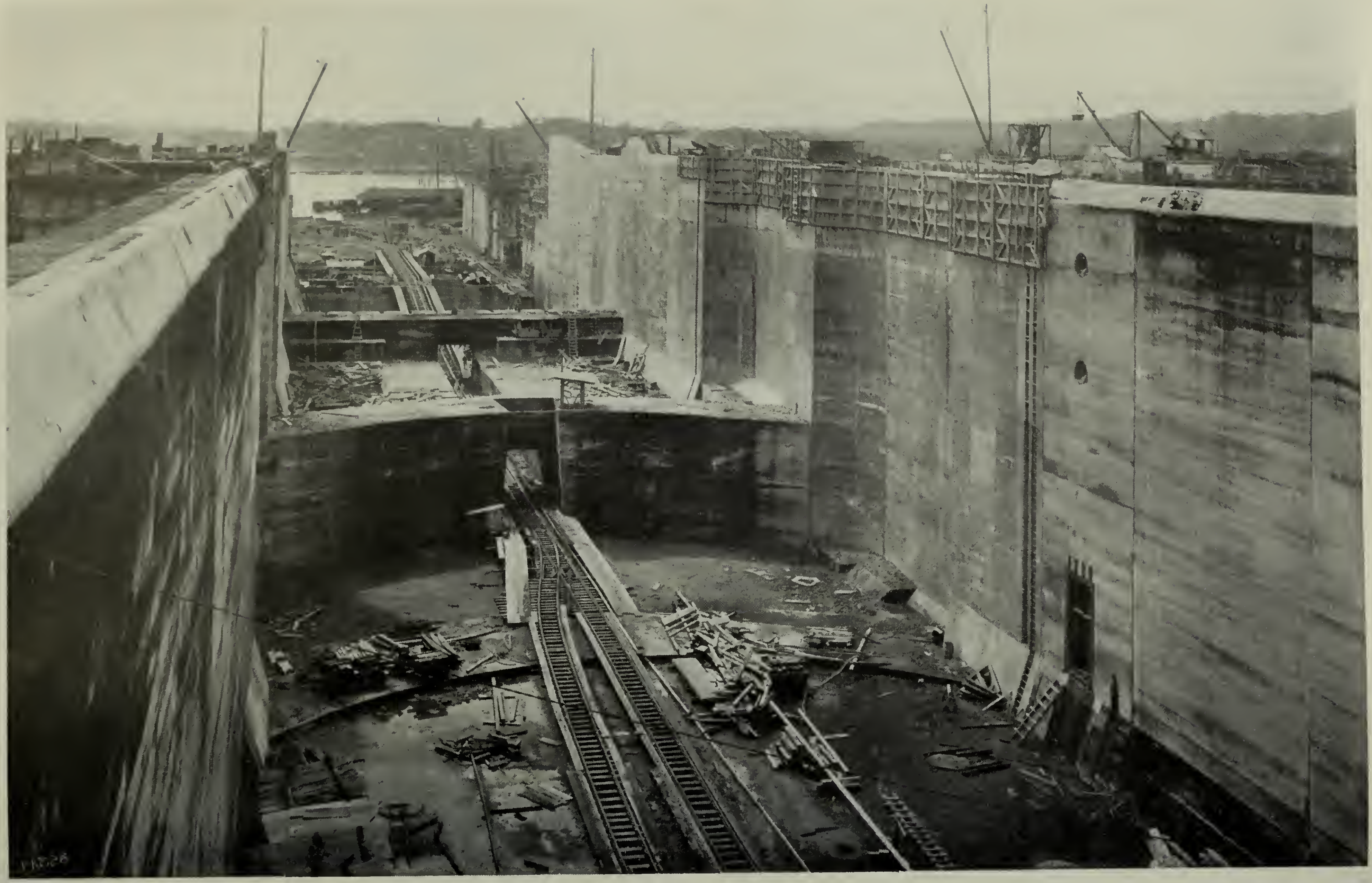


Gatun Upper Locks. View Showing Gate Sills.
Concrete Construction in the Panama Canal.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume VI. No. 5. LONDON, MAY, 1911.

EDITORIAL NOTES.

NEXT MEETING OF THE INTERNATIONAL TESTING ASSOCIATION.

THE International Testing Association meets next year in the United States, and we would suggest that the British members make timely preparations as to the part they intend to play at the Conferences to be held, so that the absence of cohesion in our deputations to the Association be less marked than heretofore, and our technical contributions to the international work more distinctive in quality and quantity than on former occasions.

England plays a very secondary *rôle* in centres of international research, such as the meetings of this body—its position ranks with that of the minor States. This is not as it should be, for we can boast of quite a considerable amount of good research work done, and even if the compilation of the data resulting therefrom be somewhat fragmentary, and if we lack a Testing Association of our own to systematise our work, as in several other countries, there is no need to " hide our light under a bushel ! "

This journal is primarily concerned with concrete, reinforced concrete, and Portland cement, dealt with in Group II. of the Association. What are termed " principal questions " in this group are as follows, and these will be dealt with at the Congress by the members named in brackets :

Reinforced concrete. (*Referee :* F. Schüle, Zurich.)
Strength of hydraulic cements. (*Referee :* F. Schüle, Zurich.)
Constancy of volume. (*Referee :* Bertram Blount, London.)
Tests of the setting of cements. (*Referee not yet named.*)
Cement in sea-water. (*Referee :* E. Leduc, Paris.)
Weathering resistance of building stones. (*Referee :* A. Hanisch, Vienna.)

The general " problems " under review at the Conference include the following :

Weathering qualities of building stones.
Influence of mortar and stones on the weathering of the masonry.
Rapid strength tests of cement.
Adhesive qualities of hydraulic cements.
Puzzolanas.
Finest particles in Portland cement.
Cement in sea water :
  (*a*) Behaviour of sea structures.
  (*b*) Specially prepared cements in sea-water.
Constancy of volume.
Reinforced concrete.
Tests of cements by prisms and standard sand.

The absence, with one exception, of British or Colonial names among the referees makes unpleasant reading, but there is time to remedy the defect, and we would earnestly remind the British delegates on the Council of the International Testing Association to make an effort to obtain the co-operation of our countrymen both in the active chairmanship or office of hon. secretaries of "Problem Committees," in the position of "referees," and in the contribution of papers as far as concrete, reinforced concrete, and Portland cement are concerned.

We suggest that during the coming summer a meeting of the British members of the International Testing Association be called to arrange for the preliminaries as to suitable collaboration in the work—as distinct from the festivities—of next year's congress.

THE CONSISTENCY OF CONCRETE.

The amount of water which should be mixed with concrete is a matter that engineers have endeavoured to regulate by the insertion of clauses in specifications, but it is rather difficult to come to any definite conclusions. Experiments in the laboratory have shown that the drier a concrete is, when properly rammed, the greater its strength. There is a considerable disproportion between dry and wet mixtures of concrete in the early stages of the hardening, but this difference becomes less as time goes on—that is to say, the strength of a wet mixture is very nearly the same as that of a dry mixture after an interval of about six to nine months. Possibly there may be some difference between them always, because it is reasonable to suppose that the concrete which has more water with it will have more voids, by reason of the water occupying space, this meaning that the structure will not be so dense.

An excess of moisture in the laboratory makes much more difference than it does on the works. This is an important distinction, because otherwise we should have to pay more attention to dryness of the concrete both as regards reduction in compressive resistance in the first few months and the adhesion. In practice, however, the concrete is deposited on wooden centering, whereas in the laboratory it is deposited in iron moulds. The moisture does not get absorbed or dry off in an iron mould, whereas centering is considerably absorbent, and the air plays about small thicknesses of concrete and dries up a good deal of the moisture. Furthermore, on the works there cannot be the same thorough ramming as in the laboratory. It is more important to have solidity in the work than it is to have a dry concrete, for a dry concrete which has not been well rammed is weak by reason of the cavities within it, the strength of concretes depending generally upon their density.

From the practical point of view, then, a concrete cannot be made very dry, otherwise an excessive amount of ramming would be required, and this might be scamped by the workmen, and in reinforced concrete scamping at any particular point might result in failure. However, it is possible in ordinary concrete and in mass concrete to employ mixtures that are comparatively much drier than we can employ in reinforced concrete work as a rule, the reason for this being that in the latter the material must be fairly moist to work in between closely spaced reinforcements. Particularly is this so in beams, and especially at the ends of beams—that is, at the points of support—for at such places in continuous beams top and bottom reinforcements are used, and bars crossing with each other and cranked up over neighbouring bars, producing such a close massing of the steel that the concrete needs to be almost in the nature of grout to pass between the bars. In plain mass concrete, on the other hand, and in reinforced concrete work where the steel bars are spaced widely apart, and some thickness of concrete is employed, such as in arched bridges and foundations, the concrete is preferably made drier, because with some thickness of concrete the tamping or ramming causes the overplus of moisture in each quantity that is deposited to gradually accumulate, until the last lots of concrete that are deposited often need to be put in practically dry to overcome the slushiness that would otherwise result. In such thick work, too, there is not the same amount of moisture removed in drying out in the air, nor, of course, does the centering remove so much by absorption, nor is there such loss of moisture by dripping through the boards. The condition of the atmosphere and the sunshine must naturally affect the amount of water that should be employed in the mixing, for it will remove more or less by evaporation. The dryness of the timber used in the centering also affects the matter.

CONSISTENCY OF THE CONCRETE IN MOULDED WORK.

In the above discussion we have excluded from our view moulded or shop work, though this journal, dealing with the whole aspect of concrete, is equally concerned therewith. In shop work we may say generally that dry mixtures are favoured because they enable the moulds to be removed sooner than can be done with wet mixtures, and, of course, the cost of the moulds is so considerable that every endeavour is made to reduce the time which the materials have to remain in the moulds in order to enable a small stock of moulds to be employed. With this object, indeed, quick-setting cements are often used. The danger of insufficient ramming of dry mixtures is not so great in shop work, as the articles are, as a rule, not so large, and the labour is under better supervision, while men are generally employed who have been properly trained in the shop. Sometimes in shop work, too, the concrete is pressed in the moulds by mechanical or hydraulic contrivances. In such cases the risks with hand labour are avoided, but very often such pressing, though it makes the materials cohere so that the moulds can be removed almost immediately, does not always ensure a dense concrete, the pressure not causing the aggregate to wedge itself together, a more or less arching action taking place within the mould. This is the reason why shaking tables are preferred where machinery is employed, though even with such shaking tables the mixture cannot be quite so dry as when the work is pressed ; but still, the proportion of moisture is small, and the moulds can be speedily removed.

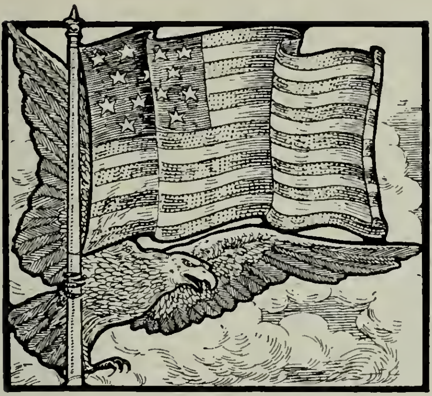
Specifications for work done *in situ* often require the water to come to the surface with moderate ramming. Some specifications stipulate that when the concrete is rammed there shall not be any serious quaking in the mass. That, perhaps, is a form of wording which would not be generally preferred. Other specifications go to the other extreme, and state that the material shall be sufficiently fluid that only a little ramming is required. For ordinary mass concrete work it seems to be generally specified that the concrete shall be what may be called a medium mixture, which shall hold together when squeezed in the hand, but shall not show moisture in the heap, and shall not quake on ramming.

For reinforced concrete work it seems to be becoming a custom to generally employ a wet mixture. In America this is often called "mushy"; and, indeed, it is often so soft that it must be handled carefully to prevent it from running off the shovel. In England it seems to be preferred that it shall be in the condition that it shows moisture in the heap on any surface that may be made by striking or smacking the heap with a shovel. The concrete on the mixing platform should not be so wet that the water runs away from the heap, for then it tends to a segregation of the cement at the bottom, and, indeed, might lead to the cement being lost by being carried away with the water that escapes. In mass foundations, where the concrete may be required to sustain heavy compression one month after placing, the concrete should be dry, and that condition is obtained when the mixture is of the consistency of damp earth. When some depth has been rammed in place, as we have said before, water rises to the surface. In placing concrete under water in dock, harbour, or river work, the concrete is generally what is known as a dry mixture, but perhaps a better term would be semi-dry, for otherwise it might be mistaken by the ignorant to apply to a mixture of materials without any water whatever. It must not be supposed that a good deal of water is required to hydrate the cement. When the cement sets the water is freed from one particle and passes on to hydrate the next, the only necessity being that we should have sufficient water there to provide for the amount that evaporates; but in time, of course, there is no need to keep the concrete moistened, for the required moisture will be absorbed from the air.

AGGREGATES AND THEIR ABSORPTION OF WATER.

In the above discussion the question of aggregates has not been considered, but different kinds of aggregates absorb different amounts of water. Where very porous or absorbent aggregates are employed it is best that they should be wetted before mixing, and therefore they do not enter into the scope of this article, which is in respect to the real factors about which there may be dispute, and about which there is difference of opinion. It is assumed that where an absorbent aggregate is being used, naturally more water would have to be used, but this extra water is best put into the aggregate to start with—namely, by wetting the material, which can be done with a hose before the sand and cement are added.

It is obvious from the foregoing that we cannot very well include in one short article a complete indication of what will be required by the engineer, or what should be adopted for the work. It is best, then, that the specification clauses should be in general terms, and that the engineer, or those responsible for the work, should indicate their wishes under different conditions, and that the mixing should be watched from day to day and varied in different parts of the work.



CONCRETE CONSTRUCTION IN THE PANAMA CANAL.

By JOHN GEO. LEIGH.

The construction of the Panama Canal is certainly one of the greatest engineering feats ever undertaken, and we feel sure that an account of the concrete work in this great undertaking will interest our readers. We are therefore devoting three articles to it, and the second instalment will appear in our June number.—ED.

In the locks alone of the Panama Canal—to ignore for the moment all reference to the other constructional works of this magnificent enterprise—there will be, when completed, no fewer than 4,446,385 cu. yds. of concrete, equivalent, in weight, to about 8,000,000 tons. The future traveller across the Central American Isthmus, passing on shipboard over what was heretofore a mountain ridge, river valley, pestiferous swamp, or luxuriant jungle, will find much to excite his lively imagination. On either side he will see a healthy region, which but few years ago was a hotbed of fell diseases. His admiration will be aroused by recollection of the long years of indomitable labour which have enabled the ship which carries him to traverse erstwhile hills. He will marvel at the great artificial lake, covering for miles what was formerly the valley of the Chagres. He may even, it is to be feared, indulge in scoffs when told that one of the unpretentious hills, scarcely less verdure-clad than its neighbours, which bound Gatun Lake at the north, is the once much-discussed Gatun Dam, foredoomed by many of its critics to slide bodily into the Caribbean Sea.

But I make bold to prophesy that the largest measure of the traveller's wonder and admiration will be reserved for the monster locks—those massive monuments of concrete, tunnelled with huge culverts, and hiding tons of intricate and carefully adjusted valves, and the most complete installation of gate and other operating machinery ever designed—in which his ship, protected against every possible danger, will be raised or lowered from one Canal level to another. These, together with the lake regulating works and great hydro-electric station in Gatun Spillway, from which will be derived all the energy needed to operate the Canal throughout its entire length—will be, in the writer's opinion, the crowning triumphs of the most remarkable engineering and constructional enterprise the world has ever seen.

Effects of Climatic Conditions.—The use of concrete in inland navigable highways is no new thing, but never before has the material been employed in large quantities under conditions such as have prevailed in the Isthmus of Panama, far from the base of supplies, and in a region blessed, or otherwise, with the abundant rains recorded in the following table :

Month.	Cristobal (Atlantic Coast).		Empire (Centre of Isthmus).		Ancon (Near Panama).		Porto Bello (Atlantic Coast).	
	1909.	1910.	1909.	1910.	1909.	1910.	1909.	1910.
January	10·61	2·94	2·28	·70	2·90	1·22	20·90	14·05
February.........	1·92	3·58	1·50	·75	2.90	·43	6·82	5·89
March	1·85	5 46	·21	1·60	·18	1·83	3·56	6·32
April..............	3·56	3·30	3·33	4·24	2 92	3·71	12 56	7·14
May	17·21	12·09	7·73	11·08	9·10	9·89	9·69	9·30
June	17·49	13·63	7·84	10·14	9·90	8·82	17·70	15·25
July	12·83	21·07	8·27	12·60	9·01	9·26	26·33	22·80
August	15·42	14·93	7·20	10·08	6·84	12·00	13·83	20·71
September	16·33	12·05	7·22	8·99	3·86	4·84	13·99	13·15
October	19·31	15·65	21·14	12·57	8·77	8·86	8·70	9·54
November	42·50	30·04	20·99	8·85	15·14	4·29	43·03	23·08
December	34·38	15·20	9·44	9·06	12·39	10·63	58·17	22·89
Total	137·41	149 94	97·15	90·66	83·91	75·78	237·28	170·12

Nevertheless, as might be proved readily by figures, rain has had but little effect upon the progress of concrete laying. The first permanent concrete work in the Canal itself, or its auxiliary works, dates from March 17th, 1909, when a commencement was made with concrete placing in the Gatun Dam spillway. Since then, from every point, the weekly and monthly records show an increased rate of efficiency and progress. Even during the most violent of storms no one ceases work ; at Gatun locks, for example, concrete is spaded into place as long as the cableway operator can see the signals of the man whose flag directs the movements of the buckets, and the rest of the work moves in consonance with this.

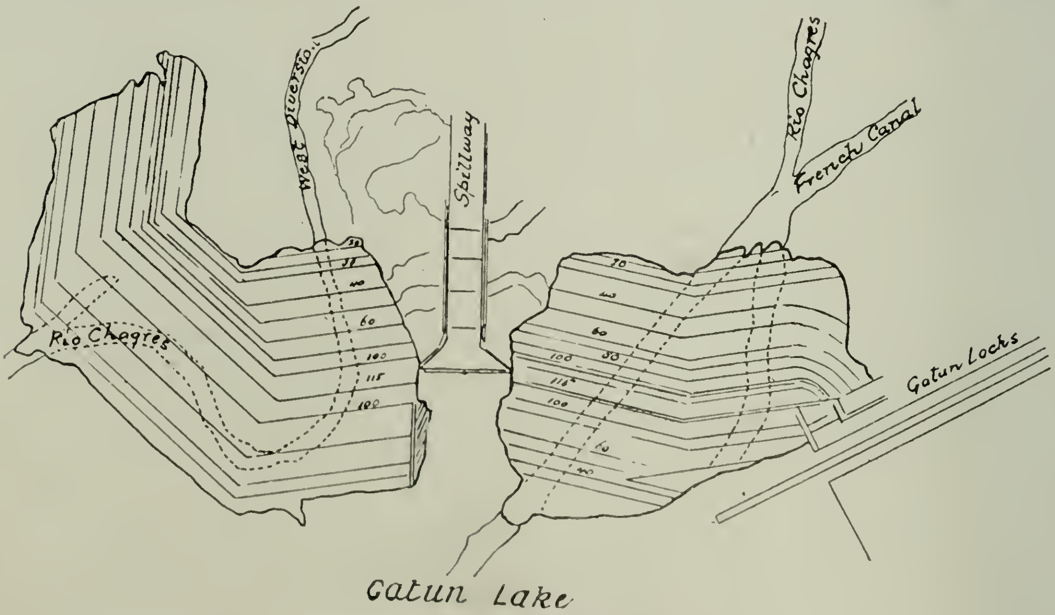


Fig. 1.—Gatun Dam.
THE CONSTRUCTION OF THE PANAMA CANAL.

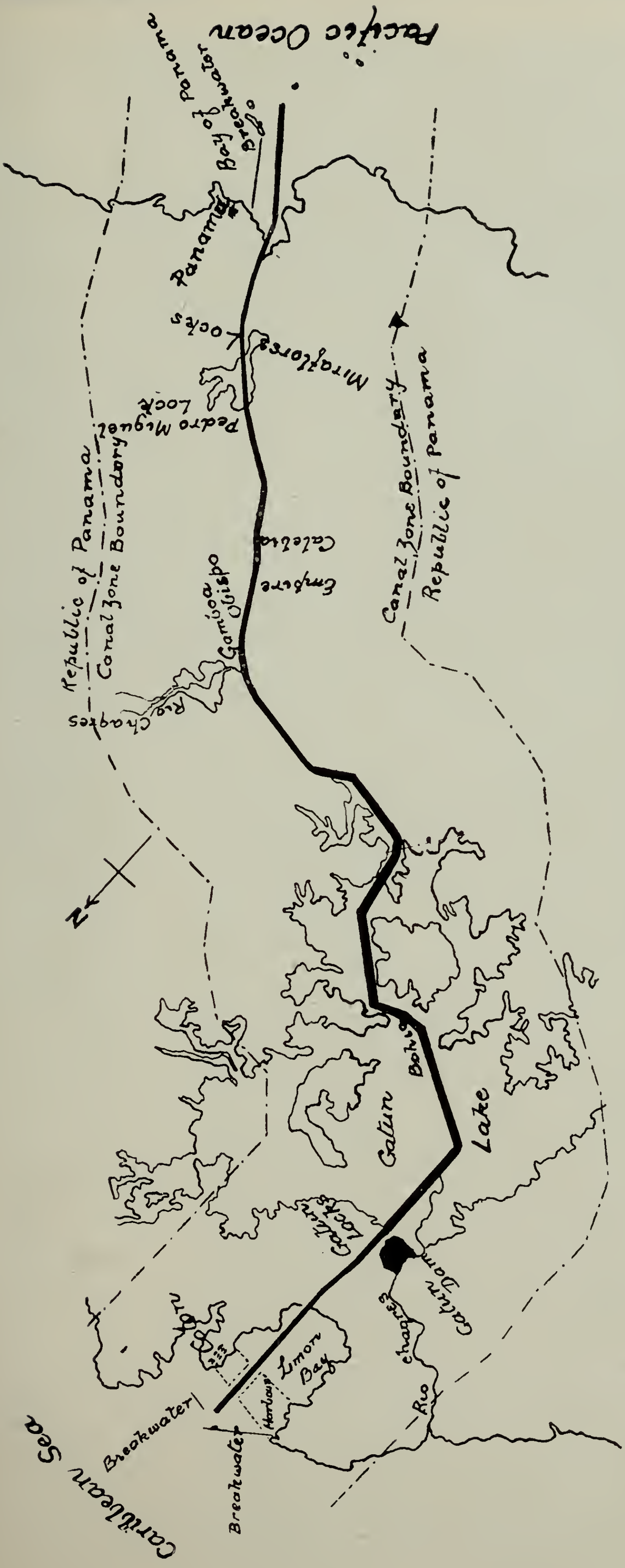


Fig. 2.—Map of the Canal Zone.
The Construction of the Panama Canal.

As to the effect upon concrete of the warm climate and the extreme humidity prevalent at all times, and particularly during the rainy season, observations are of the most encouraging character. So far from being harmful, the climatic conditions of the Isthmus appear to be particularly favourable to concrete work, inasmuch as the humidity has been proved to hasten the process of aging—*i.e.*, the slaking of the free lime present in the material immediately after burning.

Culebra Cut and Chagres Floods. — Except incidentally or as bearing directly upon its main purpose — that of indicating the very important position which concrete constructions will occupy in the completed Canal—the present contribution must ignore purely engineering problems, their solution, and other aspects of the enterprise. As regards the topography of the Canal it must suffice to point out that nowhere in Central America has the so-called "continental divide" a lower elevaion than between Colon and Panama Bay ; and to this fact, combined with the extent and direction of the Chagres valley, must be attributed the long-established recognition of a line between these places as the ideal route for inter-oceanic maritime communication.

The two most noteworthy essentials towards triumph over the difficulties to be faced were : (1) Adequate machinery for piercing the mountain range, and organisation of a high order to secure the expeditious disposal of the excavated material ; and (2) reliable provision for protecting the Canal and the shipping traversing it against the violent floods which periodically, during the rainy season, were wont to sweep from the upper reaches of the Rio Chagres into the valley between Gamboa and the Caribbean Sea. How successful the Americans have been in respect of the first problem may be gathered from the fact that during the period between May, 1904, and March of the present year the excavation in the Culebra division alone amounted to 58,262,327 cu. yds., as against about 20,000,000 cu. yds. achieved in seven years by the first French company.

The second desideratum has been solved by closing the valley of the Chagres in the neighbourhood of Gatun by a great earthen dam, 1½ miles long, 115 ft. high along the axis, and 2,600 ft. wide at the bottom, faced and strengthened with rock at various points. This work, together with the hills east and west of the canal line, will create a basin about 175 sq. miles in area, into which all the flood-waters of the Chagres and tributary streams will be impounded to form a lake with a surface normally 85 ft. above mean sea level.

Near the centre of the dam, *Fig.* 1, facing the lake, will be the works for regulating the amount of water retained in the latter ; and below these a spillway through which the wasted water will flow on its passage to the Caribbean Sea. The sides of this channel have been faced with concrete, and the floor for a distance of 960 ft. and its entire width of 285 ft. will be similarly covered, the thickness of concrete varying from 4 ft. at the gates to 1 ft. at the north end. This concrete is being laid in monoliths 20 ft. by 30 ft. in horizontal dimensions, and the total in place on March 25th was 128,314 cu. yds.—over 51 per cent. of the 250,000 cu. yds. required.

Line and General Plan of Canal.—The Atlantic entrance to the Canal will be between two breakwaters, one 10,500 ft. and the other 5,700 ft. long, designed to protect shipping from " northers " and high waves to which Colon and Limon Bay are periodically at present exposed. Thence a channel, 500 ft. wide, dredged through the bay and excavated from the shore line, leads to Gatun, a distance of 6·76 miles. At Gatun a flight of three twin locks, each with a lift of 28⅓ ft., will raise vessels from the sea level to that of Gatun Lake, or lower them from the lake to the sea-level channel. From Gatun to Bas Obispo (23·59 miles) the lake will be navigated in channels varying in bottom width from 800 ft. to 500 ft. At Obispo commences the Culebra Cut, the canal prism for a distance of 8·11 miles being 300 ft. at the bottom, the surface of the water remaining at the lake level. At Pedro Miguel is a single lock in duplicate of 30 ft. lift, by which vessels will be lowered to a small lake, created by dams closing up valleys through which flowed inconvenient streams. The channel between Pedro Miguel and the locks at Miraflores will be 500 ft. wide and nearly a mile long. At Miraflores

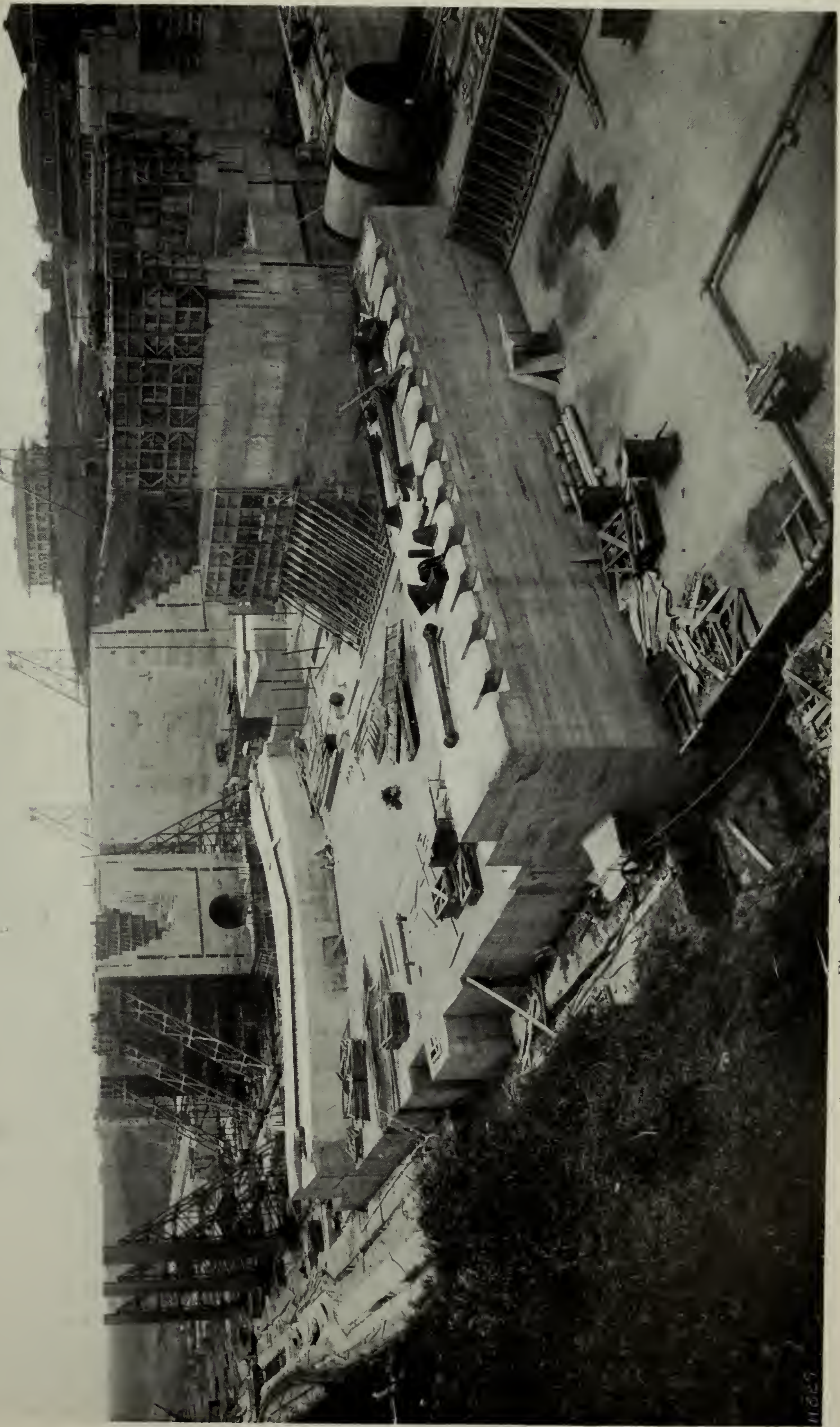


Fig. 3.—Gatun Upper Locks, looking North from West Bank.
THE CONSTRUCTION OF THE PANAMA CANAL.

the descent to the Pacific level will be made by a flight of two locks, each of

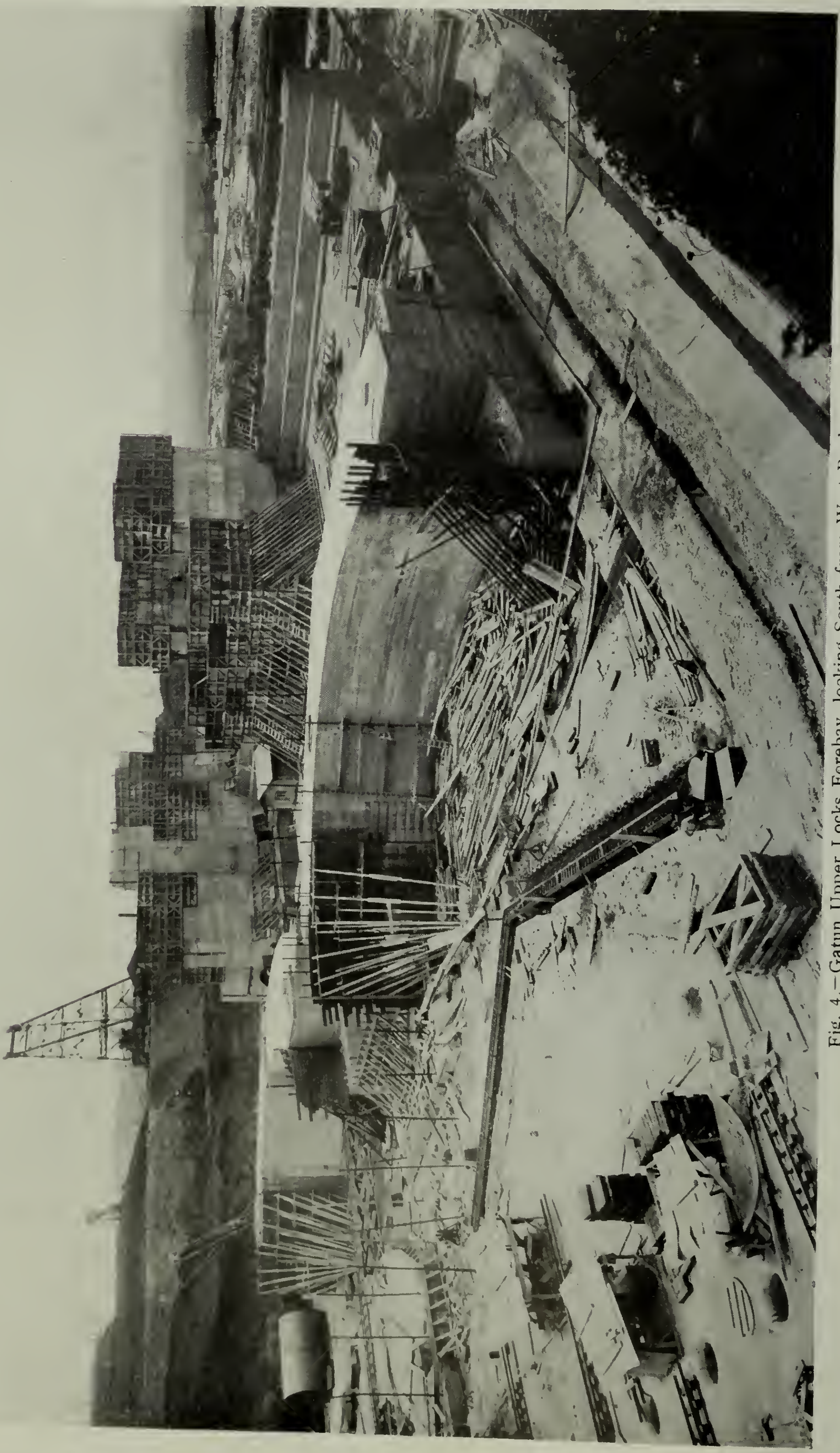


Fig. 4.—Gatun Upper Locks Forebay, looking South from West Bank.
The Construction of the Panama Canal.

27½ ft. lift; and thence to deep water in Panama Bay, a distance of 8·31 miles, the channel will be 500 ft. wide at the bottom, and 45 ft. deep at mean tide. On the east side of the Pacific entrance, between the shore and Naos Island, a rock

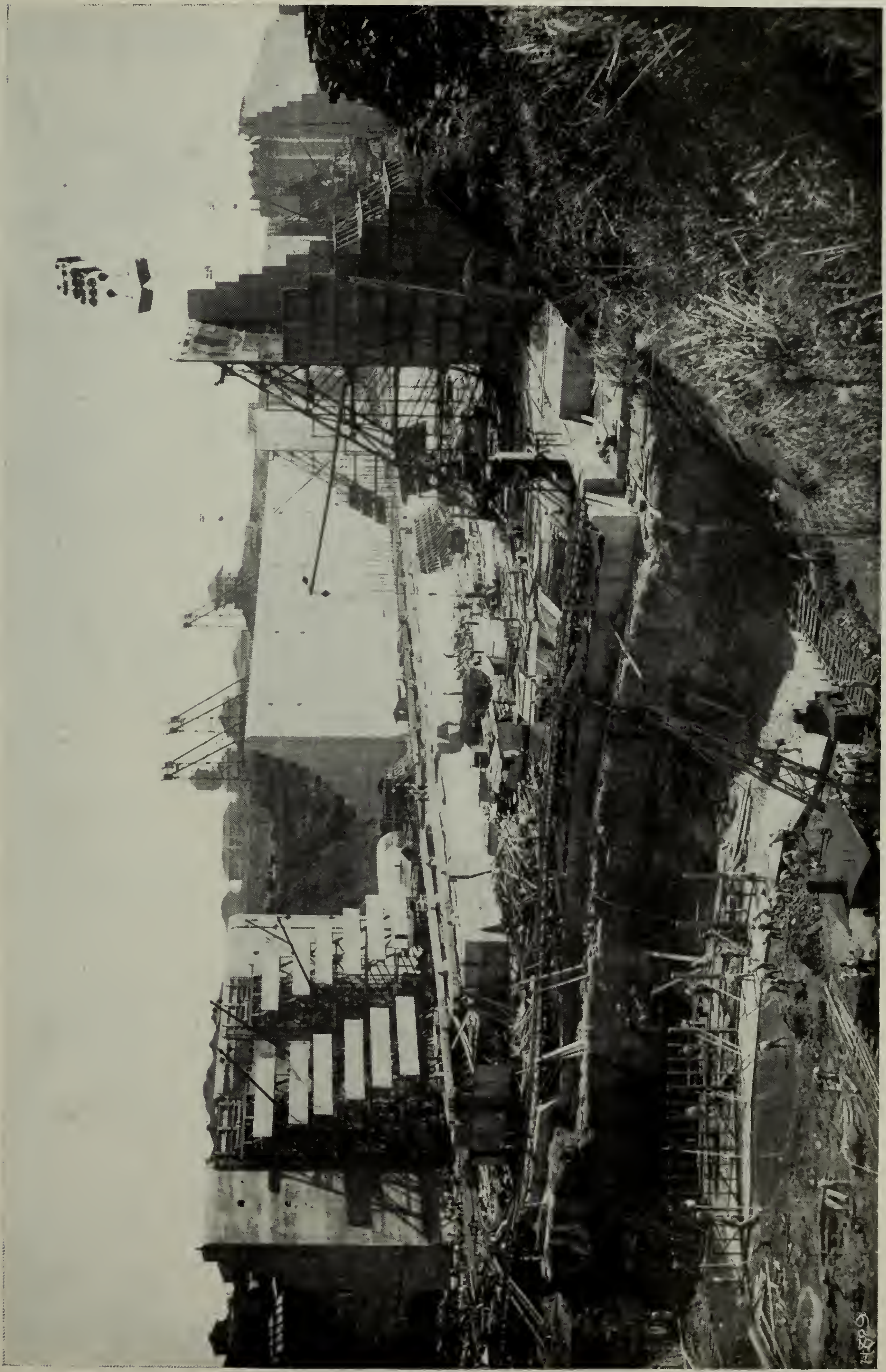
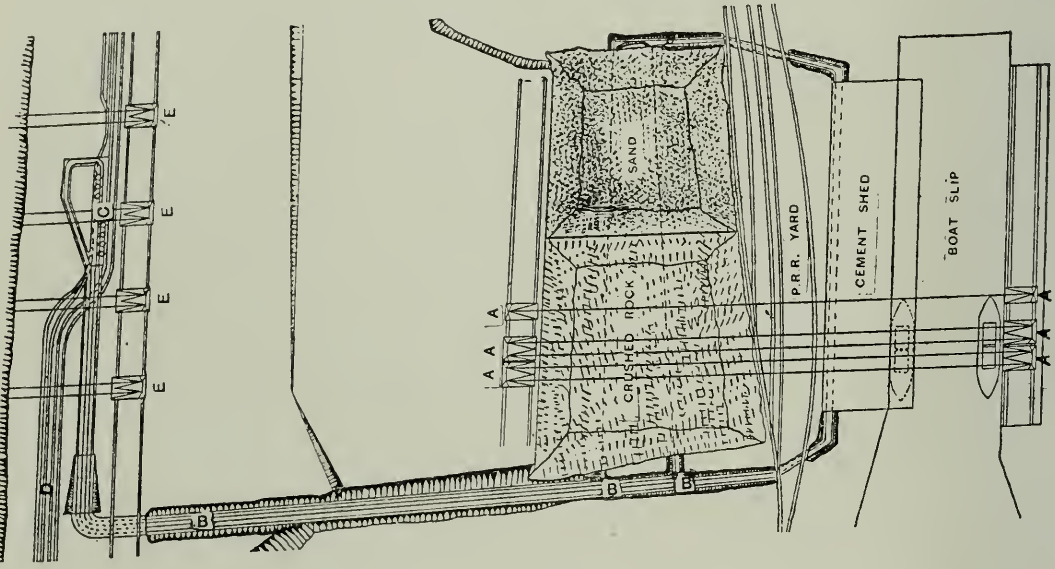


Fig. 5.—Gatun Middle Locks, looking South from West Bank.
THE CONSTRUCTION OF THE PANAMA CANAL.

breakwater is being built with a view to protect the Canal entrance from possible silt from the sandy bottom of Panama Bay.

Reinforced Lock Floors at Gatun.—In the entire length of the canal, as indicated above, there will be twelve lock chambers. All these are being built in duplicate, and of identical design and dimensions (see *Figs.* 9 and 10), the only differences in their construction being those deemed desirable as the result of local conditions. Thus, at Gatun, additional quantities of large selected rock are being embedded in the concrete, adding weight to the massive gravity section, acting as reinforcement, and sensibly reducing the cost of construction. The most important modifications, however, have reference to somewhat unsatisfactory character of portions of the rock foundation, as compared with the sites of the locks on the Pacific side. The concrete flooring, accordingly, in several places has been increased in thickness to 13 ft. or 20 ft., and is anchored down by steel rails, spaced 6 ft. apart, longitudinally and transversely, to from 10 ft. to 20 ft. in the underlying material.



a Cableways for unloading rock and sand.
b Automatic electric railway from cement, rock and sand storage to mixers.
c Mixing house.
d Electric railway on bank above locks, for hauling concrete to lock cableways.
e Cableways over locks, for delivering concrete in locks.

Fig. 6.—Concrete Handling Plant, Gatun Locks.
The Construction of the Panama Canal.

Suggested Isthmian-made Cement.—During 1906–7 a detailed examination of the section of the Isthmus to be traversed by the Canal was made by Dr. Ernest Howe, an eminent American geologist.

Dr. Howe agreed with earlier inquirers that, owing to their extensive jointing, the hard rocks of the Isthmus cannot be used for dimension stone, and that, consequently, concrete would have to be used almost exclusively for constructional purposes. He accordingly made a careful search for raw materials likely to be serviceable in the manufacture of a high grade of Portland cement, and, in the end, submitted for burning tests at the Lehigh Valley testing laboratory at

Allentown, Pa., 600 lb. of coral rock and 100 lb. each of Chagres clay and hard rhyolite tuff or breccia, deemed by him most suitable for the purpose. Considered as a whole, the test reports were not unsatisfactory, nor was the estimate that cement might be made on the Isthmus at a cost not exceeding $1.34 a barrel

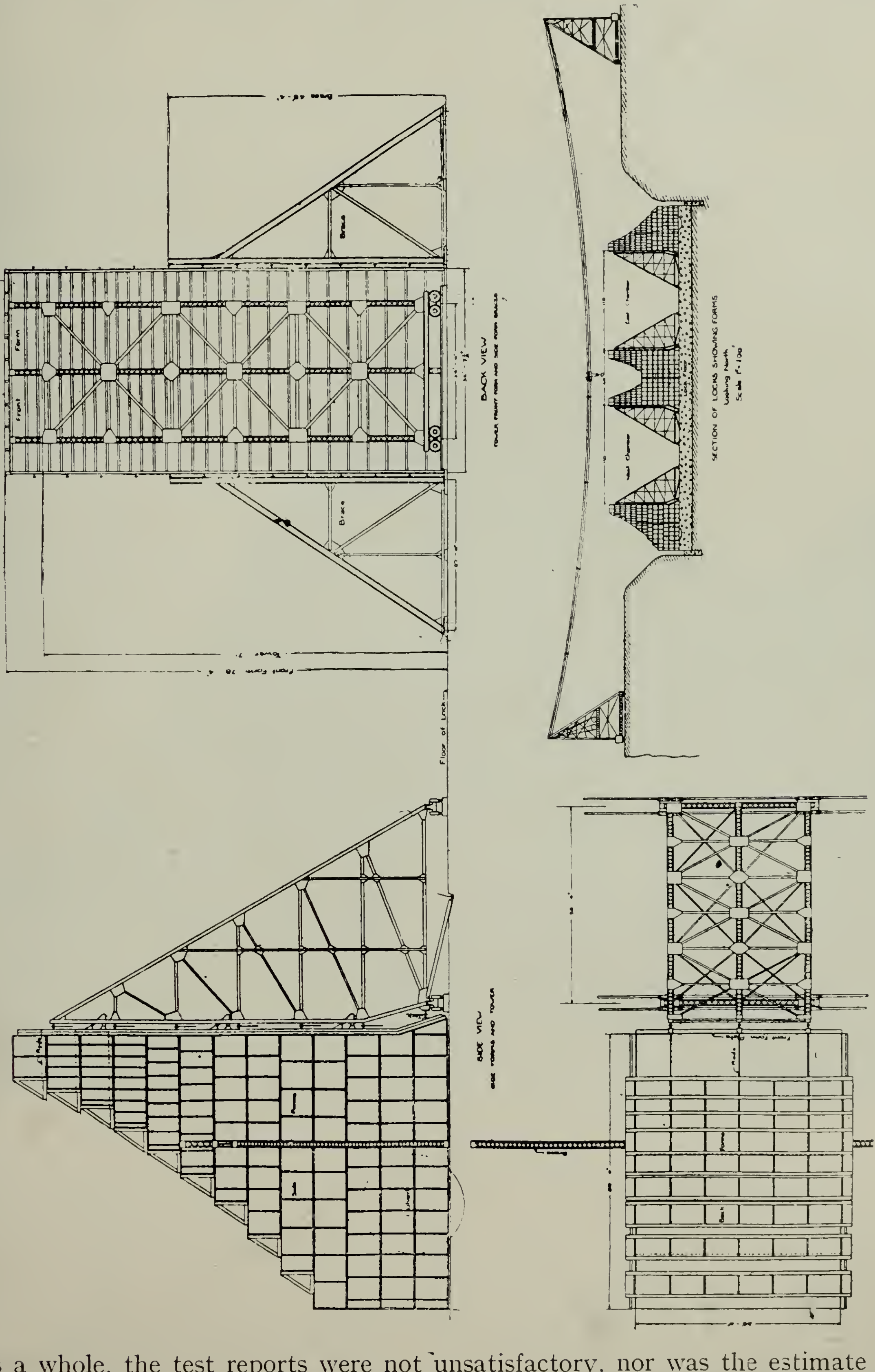


Fig. 7.—Forms for Concreting Lock Walls.
The Construction of the Panama Canal.

Nothing, however, of a practical character followed the suggestion, and in February, 1908, the Canal Commission, through its Washington office, called for proposals for furnishing 4,500,000 barrels, more or less, of Portland cement for use in lock construction.

Increased Shipments.—In January and February of last year, the contractors were directed to increase their daily shipments of cement from 1,200 barrels to respectively 2,200 and 2,800 barrels in wood, the shipments in bags remaining at 1,000 barrels. These supplies, however, were found altogether inadequate, and in May it became necessary to increase the order to 5,300 barrels daily. At that time concrete laying at Gatun locks and in the spillway called for 3,300 barrels of cement daily, in order to permit the mixing plants to run at their average rate, while at Pedro Miguel the daily requirements rose to 3,000 barrels. In February of this year, in view of the progress of work

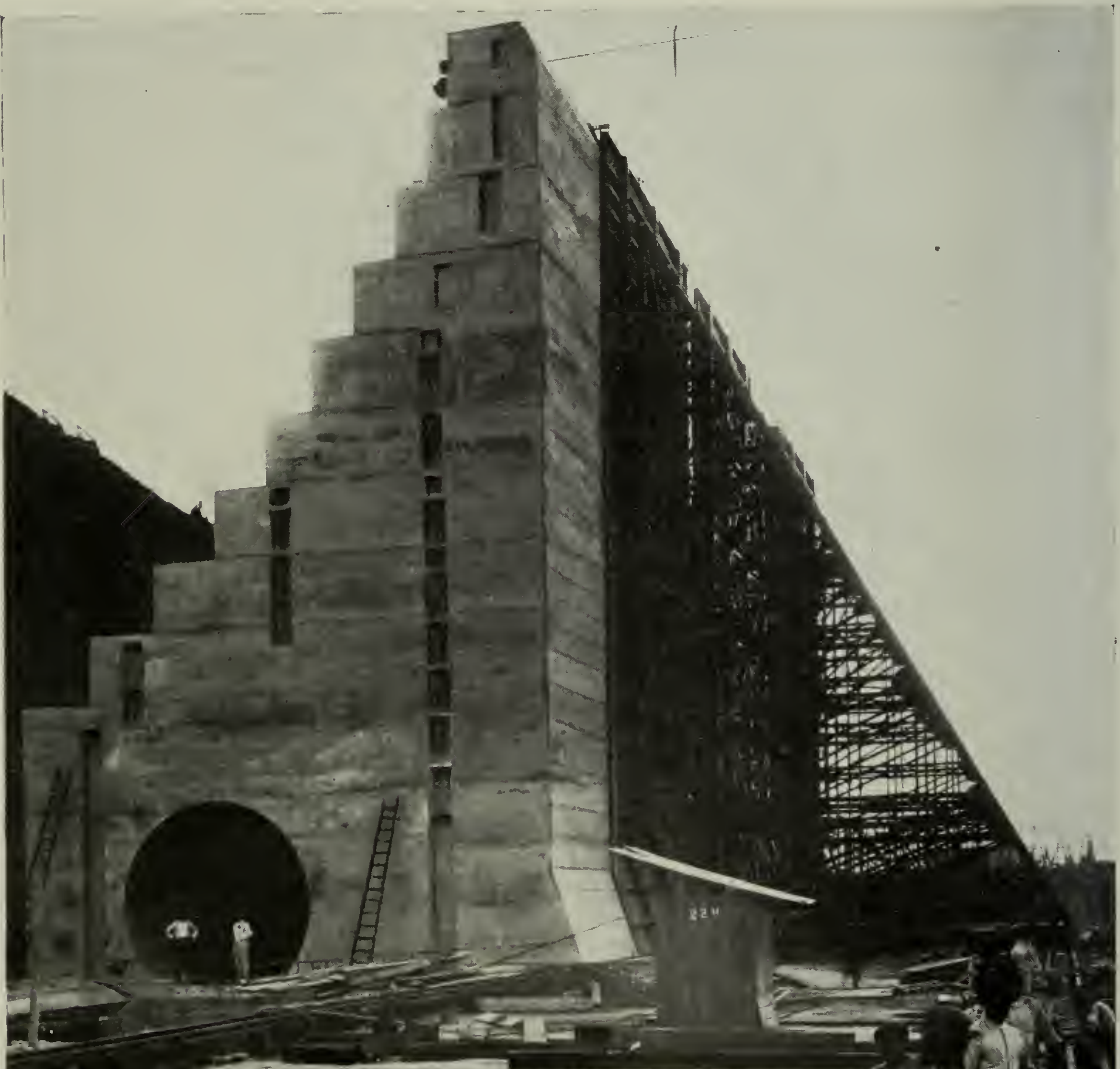


Fig. 8.—View of the First Completed Sidewall Monolith at Gatun, showing Culverts.
THE CONSTRUCTION OF THE PANAMA CANAL.

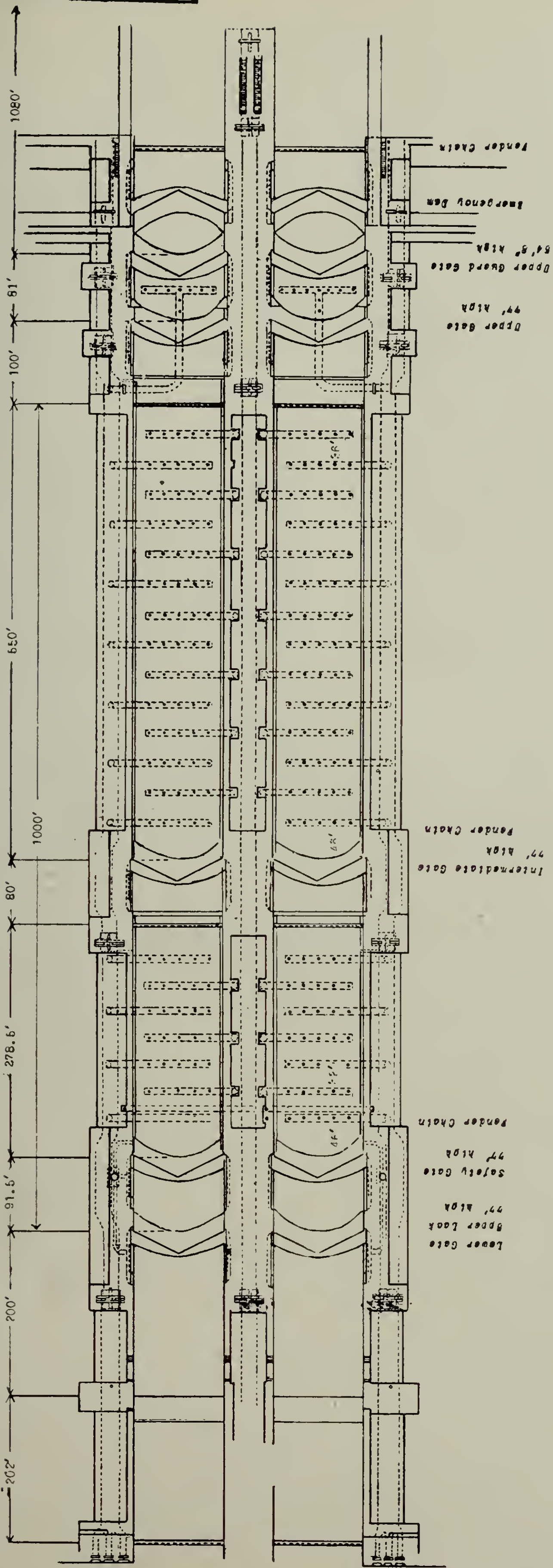


Fig. 9.—Plan of Lock Chambers.

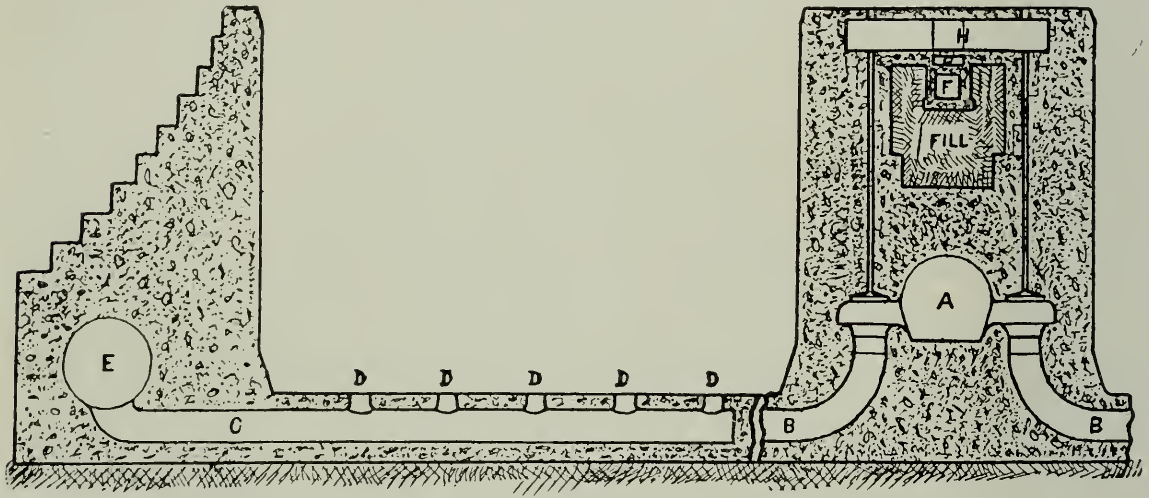
at Miraflores and the anticipated increased activity at all the lock sites during the ensuing dry season, the daily shipments were augmented to 7,000 barrels.

Local conditions are such as to make the use of barrels at Gatun slightly more convenient and economical than in the Pacific division. For this reason, and also because of the comparative dryness of the atmosphere on the Pacific slope, the greater part of the cement delivered in bags is now used at the Pedro Miguel and Miraflores locks; while most of the barrelled cement goes to Gatun, where the rainfall is heavy during nine months of the year, and rains are frequent even in the dry season.

Up to the end of November last there had been returned to the United States over 3,200,000 cement bags in good condition, and it is anticipated, taking the contract as a whole, that the Commission will secure at least 90 per cent. of the rebate claimable under it. In the absence of any market or use for them, the barrels are destroyed promptly after delivery, but most of the damaged bags are utilised, when filled with sand, in the construction of dykes.

Concrete Handling Plant at Gatun.—With the aid of *Fig.* 6 and general reference to several of the photographs included in the present article, it will be possible to describe in comparatively few words the method in operation at Gatun of handling the materials for concrete and of conveying the concrete itself to the place where it is laid.

In the vicinity of the locks, and on what is known as the old French canal, which extends from Cristobal through the swampy region east of Limon Bay, there have been constructed a boat slip and cement shed. To these from Cristobal is brought in barges the cement required for Gatun locks and the dam spillway, and thither also are transported round the coast and up the channel now available through Limon Bay, the rock quarried and crushed at Porto Bello, 17 miles east of Colon, and the sand dredged at Nombre de Dios, 18 miles further eastward. The cement is unloaded by ten electric cranes, the other materials being cared for by travelling cableways, which extend over the boat slip and cement shed and the places where the sand and rock are deposited. Underneath the cement storehouse and the rock and sand piles runs an electric railway to the battery of concrete mixers, a distance of 4,700 ft.; and along this cars pass charged in succession with cement, sand and rock in proportions of 1, 3 and 6.



a Culvert in centre wall.
b Connections between centre and lateral culverts.
c Lateral culvert.
d Wells opening from lateral culverts into lock chamber.
e Culvert in side wall.
f Drainage gallery.
g Gallery for electric wires.
h Passageway for operators.

Fig. 10.—Cross Section of Lock Chamber and Walls.
The Construction of the Panama Canal.

The cement dock has a frontage of 490 ft., is 110 ft. wide, and has a storage capacity for 100,000 barrels—about a month's supply. Over the rails on which the material cars run are 30 hoppers, into which the cement is dumped, each hopper having a valve 15 in. by 30 in. to regulate the charging. The cars are charged with sand and rock in similar manner by 22 valves, each 15 in. sq., under the sand pile; and 46 valves, 15 in. by 50 in., under the rock pile.

Mixing Plant.—In the second operation the loaded cars run up an incline to a platform erected over the mixers into which the materials are dumped. In this installation, which deals only with concrete for use in the locks, are eight mixers, each of 64 cu. ft. capacity, belt-driven by shafts making 180 revolutions a minute, with 14 revolutions a minute for the cube. They are charged by gravity from hoppers of 90 cu. ft. capacity, and receive and discharge their load without stopping or slowing down.

The tip buckets into which the concrete is dumped are carried, one to a car of 12 tons capacity, on flat, steel cars, 18 ft. long and 7 ft. wide, to a point on the west bank of the locks. Here the electric locomotive and its two cars are met by one of the eight cableways which stretch 800 ft. across the locks from steel towers, rising 85 ft. above the rails on which they move. The cableway deposits two empty buckets and picks up two full ones, which it conveys to that part of the lock where concrete is being placed. The same cableways, it may be noted, are used to lift material from the locks and dump it by an aerial dumping device, to handle forms for the concrete work, and to move parts of the gates and gate-operating machinery. When emptied, the buckets, which are nicely balanced and can be tipped with but slight effort, are hauled back to the mixers for another load.

Lock Floors and Walls.—The floors and walls of the locks are being built up in monoliths. Forms for the floor are made of timber, and are 50 ft. long, 20 ft. wide, and 20 ft. or 13 ft. high ; while those for the side and centre walls, see *Fig.* 7, are of sheet steel, carried on movable towers, also built of steel. Rails are laid close to the line of the walls, and on these the towers move up and down the lock chambers ; jacks fixed to the towers and bearing on the forms being used to align the latter and hold them in place. There are at Gatun 12 of these towers, with forms 78 ft. long from top to bottom, 36 ft. wide and 7½ in. thick, each form and tower weighing about 2,000 tons. For the sides and ends of the wall monoliths, steel girders, 6 ft. high, are built up in succession to the full height of the wall before the placing of the concrete begins, while for the backs of the walls, steel girders with triangular bracing are used.

The side walls, *Fig.* 7, are 50 ft. wide at the floor surface, and narrow from a point 24½ ft. above the latter until they are 8 ft. wide at the top. The middle wall is 60 ft. wide and 81 ft. high ; and 42½ ft. above the surface of the floor is divided into two parts, leaving a space down the centre 44 ft. wide at the top and 19 ft. wide at the bottom. In this space is a tunnel divided into three galleries—the highest serving as a passage way for the operators, the middle for the wires which will carry the electric current to operate the gate and valve machinery, and the lowest for drainage.

The Culverts.—In the case of both walls and floors, the concrete monoliths have to be laid with reference to the culverts embedded in them for the purpose of carrying the water which will be used in filling and emptying the lock chambers. There will be three main culverts extending the full length of the locks of two diameters, 22 ft. and 18 ft., the bottom of the culverts in the side walls being 2½ ft. below, and that of the culvert in the centre wall 10½ ft. above the surface of the floor.

Lateral culverts, in the form of an ellipse, 6½ ft. high and 8 ft. wide, run in the floor from and at right angles to the main culverts at intervals of 32 ft. and 36 ft., leading alternately from the side and middle culverts. By each of these culverts, the tops of which are 3 ft. below the floor surface, water will be delivered to or collected from the lock chambers through five wells in the floor.

The forms for the culverts are made of open-hearth steel, and are mounted on wheels to facilitate removal. At Gatun alone for the main culverts in the side walls there are 21 forms in 12 ft. lengths, each weighing over 138 tons; 12 forms for the middle wall culverts, each about 80 tons in weight; and 100 forms for the lateral culverts, each 10 ft. long, and weighing over 97 tons. At intervals, owing to the great velocity of the water passing through the valves, and to protect the concrete immediately below, cast-iron plates 1 in. thick are used as lining to the culverts.

Lock Chambers and Safety Provisions.—As will be observed from the plan (*Fig.* 9), the gates and valves are so arranged that chambers of varying length—278·5 ft., 370 ft., 550 ft., or 908·5 ft.—may be used. It is estimated that for the lockage of vessels approaching 550 ft. in length the use of the side culvert only will suffice, the centre culvert being employed only during the last few minutes of a lockage on the rarer occasions when the 900 ft. or 1,000 ft. chamber is required to pass a very long vessel or a number of smaller ships.

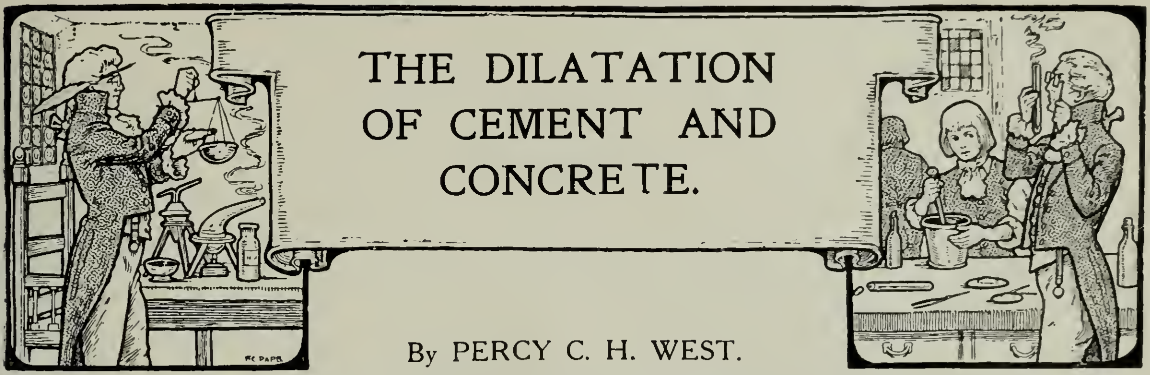
The same illustration is interesting as indicating the special provisions made to ensure the safety of shipping passing through the locks. Above and below each flight there will be long piers, against which all vessels will be required to moor before approaching within 300 ft. of the lock gates. They will then be taken in charge by powerful electric towing appliances on the lock walls and conveyed through the lock gates without use of their own power. At all important points the gates are double, and as an extra precaution there will be stretched across the lock near the water surface so-called fender chains, sufficiently strong to resist the shock of a vessel weighing 10,000 tons, and moving at a speed of 3 miles an hour, and to bring it to a standstill before it could reach the next gate. Above each lock, also, will be an emergency dam readily closed in case of accident, and calculated to check any current which might flow through the lock.

Concrete Piling for Guide Wall Construction.—The upper guide wall at Gatun locks (see *Fig.* 1) will be a continuation of the centre wall, and extend into Gatun Lake a distance of 1,500 ft. The portion nearer the lock will be of solid construction, but the remaining 850 ft. will be constructed as a reinforced concrete cellular wall, supported by reinforced concrete piles driven into the bed of the lake to depths from 20 ft. to 70 ft.

It is estimated that for the foundation of this guide wall there will be required 3,500 piles. These are now being made at Gatun of 1 part cement, 1½ parts sand, and 3 parts rock, rectangular in cross-section and reinforced by four longitudinal angles near the four corners, connected at intervals of 18 in. by lateral straps. The reinforcement is in sections 12 ft. long, so that piles of any length, in multiples of 12, may be made. On the lower end of each pile is a cast-iron shoe, while the upper end is heavily reinforced to withstand the blow of the driver.

As an additional precaution against the possibility of the concrete being crushed, a cast-iron driving head has been devised, consisting of a piston, in which is a cushion of sand, rope, and wood. The work of driving the piles was successfully commenced during the first week of March by two steam pile drivers of the skid type, having a maximum height above the ground of 93 ft. Each is equipped with steam hammers weighing over 10,000 lb., 5,000 lb. of which is in the driving part, which falls 42 in. and strikes 60 blows a minute. It is estimated that each machine is capable of driving 10 piles per day of eight hours.

(*To be continued.*)



THE DILATATION OF CEMENT AND CONCRETE.

By PERCY C. H. WEST.

The question of the contraction and expansion of cement and concrete is one that has often been discussed, and on which there is a great divergence of opinion. This article by Mr. Percy C. H. West should, therefore, be of interest to our readers.—ED.

It may be stated as a general rule that the properties of the newer materials of construction have been more closely investigated than have those of materials which have been in use from very remote periods. In fact, the study of these newer materials has revealed properties either not at all or but dimly suspected, and if known qualitatively, rarely determined quantitatively, and allowed for in actual work. The expansion and contraction of cement and concrete under varying circumstances has recently been much discussed, and it would appear that the fact that other materials possess precisely similar properties has not been sufficiently remarked

That cement mixtures expand under the effect of heat, in common with other materials, is well known; but how this expansion compares, in degree, with that exhibited by other materials is, perhaps, not sufficiently brought out. Similarly, the expansion of concrete when wetted is noted, but the fact that most natural stones show a similar expansion is left unremarked.

Bauschinger, in 1879, endeavoured to determine the change in volume of cements and cement mortars during the hardening process. The general results of his work are well known, and the apparatus devised by him, and perfected by Klebe, is now widely used for this purpose. In 1881, Schumann reported the results of numerous determinations of the variation in length of test-pieces of cement and mortars during setting. He found that all cements expanded if immersed in water, and that this expansion continued, at least, up to one year. The cements employed by him, which were of the normal composition of the period, expanded from 0·000592 to 0·00255 of their length. If mixed with sand the expansion was much reduced; the normal mortar (3 sand, 1 cement) giving values from 0·0001 to 0·000574 if immersed for two years.

During the earlier period of the hardening the expansion was greatest, and gradually fell off as the age of the specimen advanced. From 24 hours to 7 days the expansion varied between 0·0012 and 0·00014 with the prisms of neat cement and 0·000044 and 0·0039 with the normal mortar.

Later, Schumann published a further series of results exhibiting lower expansions, and attributed this to the improved methods of manufacture introduced during the intervening period. His results published in 1889 extended over a period of five years, and cover a series of seven cements. The total expansion of the normal mortar in this case was found to vary from 0·000137 to 0·0005, and averaging 0·000316 of the total length. The average course of the expansio is represented in the following table:

EXPANSION IN MMS. OF A PRISM 10 CMS. IN LENGTH IMMERSED IN WATER.

Up to 7 Days.	1–4 Weeks.	4–13 Weeks.	13–26 Weeks.	26-52 Weeks.
0·0123	0·0051	0·0025	0·0029	0·0052
	1–1½ Years	1½–2 Years	2–5 Years	
	0·0013	0·0007	0·0016	

These figures have been frequently referred to and used for comparison. The very considerable variations from the mean and the considerable advances which have been made in the methods of manufacture preclude their being adopted as a rigid standard. As will be seen, the average of these tests at two years gives an expansion of 0·0003 of the original length. Kasai, in a work published in 1907, does not obtain any expansion greater than this, and most of his results show a distinctly smaller expansion. Similarly, Schindler, employing cements containing up to 4 per cent. of sulphuric anhydride, obtained as the highest value at six months, 0·00078; with a cement containing only 1·32 per cent., the figure 0·00052 was not exceeded.

Dyckerhoff and Durand-Claye and Debray observed high expansions with cements containing large percentages of magnesia. Such cements being, however, of abnormal composition are of little interest in this connection.

Campbell and White obtained as a maximum 0·000144 at five years for a normal Portland cement. It may therefore be considered that the normal expansion of Portland cement resulting from the setting process, in contact with water, though a variable quantity, is known, the maximum and minimum being found from the results of several investigators.

In order to determine the relation of the expansion of the various hydraulic cements, Schumann carried out an interesting series of experiments. A mixture of 4 parts trass, 3 of lime, and 2 of sand gave an expansion of 0·000186 at one year. Hydraulic limes mixed in the proportions of 1 lime to 3 sand gave expansions over the same period of 0·000315 and 0·000586. In these cases the expansion was approximately the same during the second six months as during the first. Later, Dyckerhoff found that the iron Portland cements gave a greater expansion than did the true Portland cements; a result confirmed by Burchartz, of the Royal Material Station at Gross Lichterfeldt.

This slight expansion of cement mortars and of cement, when immersed in water, is independent of the expansion due to over liming or bad preparation. It is not due to an excess of gypsum; neither is it a feature only observed with Portland cement. Schindler has shown that only with a proportion of gypsum exceeding a percentage of 2·3 of sulphuric anhydride in the cement is an abnormal expansion observed.

Not only do cement mortars expand when exposed to the action of water; bricks and the majority of building stones are similarly affected. Schumann tested prisms 10 centimetres long of various materials, and found that after two weeks' immersion, bricks showed an expansion varying from 0·00006 to 0·00019 of the total length.

Sandstone	from	0·00006 to 0·00206	
Limestone	,,	0·00004 ,, 0·00260	
Granite and basalt...	,,	0·00006 ,, 0·00048	

A most important point in this connection is the reduction in the strength of the stone in consequence of the absorption of water. Gary and others have shown that the strength of a stone which has absorbed 1 or 2 per cent. is often less than 70 per cent. of that of the dry stone.

Exposed to air, a stone contracts on drying-out. Schumann found that this contraction varied as follows:

Brick	0·00008 to 0·00015
Sandstone	0·00018 ,, 0·00178
Limestone	0·00008 ,, 0·00026
Granite and basalt...	0·00015 ,, 0·00050

To Schumann's results it has been objected that such experiments should be carried out on longer prisms than were used by him. His results, however, indicate a regular expansion on immersion and a regular contraction on drying-out. They may not be average figures for the stone from the quarry, but they show that such alterations do occur.

Schumann showed that Portland cement mortars (1 cement, 3 sand) after one week's storage in water followed by three weeks in air, exhibited a contraction varying from 0·0004 to 0·00045. An hydraulic lime mortar of similar composition gave a contraction of 0·0011. A 4 trass, 3 lime, 2 sand mixture gave a contraction of 0·00133.

Tomëi also tested various mortars, and his results are tabulated below:

Age.		7 Days.	28 Days.	3 Months.	6 Months.	1 Year.
Weight of sand to 1 cement	(0)	0·00026	0·00093	0·00107	0·00194	0·0026
	(1)	0·00037	0·00050	0·00087	0·00093	0·0016
	(3)	0·00025	0·00035	0·00060	0·00065	0·00125
	(6)	0·00025	0·00025	0·00045	0·00057	0·0000

The maximum and minimum results obtained by Tomêi and Grauer are given below:

	7 Days.	28 Days.	3 Months.	6 Months.	1 Year.
Tomëi (min.) ...	0·00010	0·00020	0·00060	0·00067	0·0010
,, (max.) ...	0·00047	0·00075	0·00123	0·00165	0·00195
Grauer (min.) ...	—	—	—	0·00015	0·00040
,, (max.) ...	—	—	0·0015	0·0019	0·00225

	2 Years.	3½ Years.	5 Years.
Grauer (min.)	0·00050	0·00065	0·0012
,, (max.)...	0·00250	0·00285	0·0030

Dyckerhoff found that the iron Portland cements contracted more on drying-out than did the true Portland cements. Burchartz was unable to confirm this result, finding, in fact, that the two classes behaved similarly. The figures given below indicate the close agreement found by the latter investigator.

CONTRACTION OF CEMENT MORTARS.

Normal Mortars (1 cement, 3 sand). Stored in Air.

		7 Days.	28 Days.	6 Months.	1 Year.	2 Years.
Portland cement	(B)	0·00028	0·00044	0·0081	0·00087	0·00081
	(D)	0·00032	0·00062	0·00109	0·00115	0·00115
Iron	(G)	0·00041	0·00048	0·00093	0·00088	0·00088
Portland cement	(H)	0·00033	0·00053	0·00102	0·00103	0·00115

Schüle has also investigated the shrinkage of cement mortars when exposed to air, using a measuring bench for this purpose instead of the Bauschinger callipers.

Generally expressed, his results show that the greatest contraction is shown by neat Roman cement and with normal mortars by the slag cements. At the same time, it may be mentioned that he found that the Portland cements showed very marked variations.

CONTRACTION OF CEMENTS AND MORTARS (SCHÜLE) EXPOSED TO AIR.

	Up to 28 Days.	Up to 2 Years.
Portland cement (neat)	0·00302	0·00470
,, ,, (1 : 3)	0·00128	0·00176
Slag cement (neat)	0·00272	0·00433
,, ,, (1 : 3)	0·00160	0·00206
Roman cement (neat)	0·00308	0·00500
,, ,, (1 : 3)	0·00065	0·00117
Hydraulic lime (neat)	0·00243	0·00260
,, ,, (1 : 3)	0·00070	0·00086

The thermal properties of building stones have received relatively little attention, with the result that comparisons between the expansion of concrete and of stone are not so satisfactory as might be wished. Hirschwald, in his book on the testing of building stone, gives but little information on this point. He gives, however, some interesting cases illustrating the effect of heat.

In Texas, at Sierra de los Dolores, there is a block of granite 6 metres long, 4½ metres high, originally formed like a roller with rounded ends, now split into several pieces like an apple cut with a knife. Other cases occur in which shell-like layers have been split off large blocks of stone. In all these cases these phenomena are the combined effect of the poor heat conductivity of the stones and the relatively considerable expansion due to rise in temperature. In temperate climates the diurnal variation in temperature is not considerable; the seasonal variation is greater, but is more gradual. The variation in tropical climates is greater; in fact, a drop of as much as 60 degrees Centigrade has been observed, consequent upon a rain storm.

The poor heat-conducting qualities of both natural and artificial stones leads to a considerable difference in temperature between the exterior and the interior of a mass of stone, resulting in a certain amount of strain. The advantages of the poor heat conductivity are apparent; the effects of the rise in temperature are localised, and in a structure a member would have to be exposed to a given temperature for a long period in order to expand as a whole. Actual determinations have shown a difference of 15 degrees in one centimetre with stone. A series of determinations of the thermal conductivity of concrete have been made by Professor Norton, of the University of Massachusetts. The results show that a 1 : 2 : 5 broken stone-cement-concrete has a coefficient of thermal conductivity of 0·0022 cals. per degree centigrade per square centimetre per second.

The coefficient of linear expansion of quartz has been accurately determined and found to be, parallel to the crystalline axis, 0·00000797 per degree centigrade; vertical to the axis, 0·00001337. A Calc-Spar crystal has a negative coefficient of expansion at right angles to the axis, the actual coefficients being:

Parallel to axis...	+0·0000263
Right angles to axis	−0·00000544

The above figures have but little value in actual work.

For more useful data we must turn to the work of Bouniceau (1863). The coefficients of cement concrete, masonry, and various building stones were determined by him through a range of 80 degrees. The averages are tabulated below :

Material.	Coefficient Linear Expansion Per Degree Centigrade.
Portland cement (neat), immersed after setting ...	0·0000107
Portland cement mortar (2 sand, 1 cement) ...	0·0000118
Brickwork set in above (headers)	0·0000089
,, ,, ,, (stretchers)	0·0000046
Stone from Ranville (limestone)	0·0000075
,, ,, Caen (limestone)	0·0000089
,, ,, Diélette (granite)	0·0000079
Marble	0·0000054
Plaster floating	0·0000166

Forcheimer refers to the employment of the coefficient at 0·00001 in calculating the expansion of dams due to change in temperature. Professor Pence has obtained a figure in close agreement with this—namely, 0·0000108 for limestone. This figure agrees very closely with those obtained by the same investigator for cement concrete.

The Ecole des Ponts et Chaussées have obtained the following results for the different classes of cement:

Cement.	Maximum.	Minimum.	Mean.
Hydraulic lime	0·0000103	0·0000111	0·0000108
Grappier cement ...	0·0000094	0·0000103	0·000010
Portland cement ...	0·0000093	0·0000111	0·0000099
Slag cement	0·0000077	0·0000117	0·0000996

It will be observed that the coefficients obtained do not agree with the determinations of Bauschinger, a figure which is often adopted, of 0·00000865.

Keller (1894) determined the coefficient of linear expansion of Portland cement and of gravel concrete. The aggregate consisted of sand and gravel in equal parts, the latter not exceeding 2 centimetres. He found, broadly speaking, that the poorer the mixture the lower the expansion The actual figures are given :

Parts aggregate to cement ...	0	1	2
Expansion per degree centigrade...	0·0000126	0·0000111	0·000010
Parts aggregate to 1 part cement...	4	6	8
Expansion	0·0000104	0·0000092	0·0000095

The figures given above for the expansion of neat cement are exceptionally high, the other figures agree fairly well with those obtained by other investigators.

Among the most recent results are those of Professor Pence, of the Purdue University. It was originally proposed to carry out a most extensive series of tests, but for certain reasons, among which may be put the close agreement shown by the various mixtures, the work has not been continued. For the determinations in the first series, prisms of square section, 36 in. in area and 24 in. in length, were employed ; in the second series, cylinders 4 in. in diameter and 36 in. in length were used Both gravel and broken stone concrete were tested, and the results were in such close agreement that the difference lay within the experimental error. Similarly, various brands of cement appeared to have the same coefficient. A bar of the limestone employed in the broken stone concrete gave a coefficient but slightly differing from that of the 1 : 5 concrete. All the mixtures tested were moulded fairly dry, the percentage of water being regulated to give a quaking mass when rammed into the mould.

Coefficient of Linear Expansion of Concrete (Pence).

Series.	Mixers.	Cement.	Coefficient.
1st	1 : 2 : 4	Lehigh	0·00000972
,,	1 : 5	Medusa	0·0000099
2nd	1 : 5	,,	0·00000972
,,	1 : 5	,,	0·00000954

These results have been confirmed, in the main, by Professor Norton, who finds that the expansion between 0 and 100 degrees is 0·0000099, increasing slightly up to 300 degrees, falling from this point to zero at 815 degrees, then becoming slightly negative. On cooling from such a high temperature it was observed that the test-pieces did not return to their original length, but retained an elongation equal to 70 per cent. of the total.

The numerous factors causing an alteration in volume of concrete test-pieces has doubtless militated against the agreement among the results of different investigators. The contraction of cement masses, due to loss of water, has a considerable effect, as shown by the results of Schumann and Keller, and consequently a correction should be made in determinations of the expansion due to heat. If such a correction be not made, the results are of value in actual work, but their scientific value is reduced, while even for practical purposes their value is limited.

The following results obtained at the Ecole des Ponts et Chaussées are most useful as illustrating the contraction resulting from the drying-out and the fall in temperature. They, however, do not indicate the relative magnitude of the several factors.

The concrete employed in these experiments was composed of 300 kgs. of Portland cement to 0·4 cubic metres of Seine sand passing the 5 mm. screen, and 0·8 cubic metres shingle passing the 25 mm. screen. The amount of water used was equal to 8·2 per cent. of the dry matter. Prisms, moulded vertically, 1 metre long, were made of this mixture. Three of these prisms were of square section, 225 square centimetres in section. One was armoured longitudinally with four bars 12 mms. in diameter, the reinforcement being 2 per cent. Two were of plain concrete, one being allowed to dry out, the other being kept moist by means of sacks. The remaining test-piece was of octagonal section, and was reinforced by six bars, 7 mms. in diameter, equivalent to a reinforcement of 1 per cent. and wound with wire 7 mms. in diameter, in the form of a spiral 27·5 mms. pitch ; equal to a reinforcement of 2·5 per cent. The results obtained are tabulated below :

Variation in Length of Concrete Prisms.

(Ecole des Ponts et Chaussées.)

Iron Bar as Standard.

Age.	Temperature.	Contraction.
—	24	0
—	25	0
—	23·5	0·00002
—	19·7	0·00006
—	14·5	0·00014
—	10·0	0·00020

Spirally Armoured Prism (Dry).

Age.	Temperature.	Contraction.
3 days	24	0
14 ,,	25	0·00014
32 ,,	23·5	0·00025
49 ,,	19·7	0·00029
95 ,,	14·6	0·00045
151 ,,	10	0·00055

Longitudinally Armoured Prism (Dry).

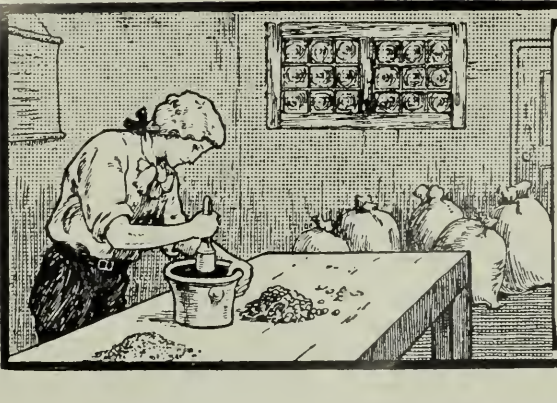
Age.	Temperature.	Contraction.
3 days	24	0
13 ,,	25	0·00013
31 ,,	23·5	0·00021
48 ,,	19·7	0·00024
94 ,,	14·5	0·00040
150 ,,	10·0	0·00050

Unreinforced Prism (Dry).

Age.	Temperature.	Contraction.
3 days	24	0
12 ,,	24	0·00011
30 ,,	23·5	0·00021
47 ,,	19·7	0·00026
93 ,,	14·5	0·00043
149 ,,	10·0	0·00053

Unreinforced Prism (Kept Moist).

Age.	Temperature.	Contraction.
3 days	25	0
30 ,,	22·5	0
47 ,,	20·5	0·00002
93 ,,	11·0	0·00015
149 ,,	7	0·00020



CONCRETE MIXERS.

In some former issues we published articles on the different appliances for concrete making, and we now intend giving a further series of articles on additional concrete mixers.—ED.

THE TRUMP MEASURING AND MIXING MACHINE.

THE advantages of machine mixing over hand mixing are universally recognised nowadays, and for work of any magnitude machines are always employed for mixing concrete.

There are several types of machines, which can be divided roughly into two main classes—(1) batch mixers, and (2) continuous mixers. The former mixes a specified quantity of concrete at a time, consequently the materials have to be measured by hand and filled into the machine. Continuous mixers, however, give a regular discharge of concrete.

Some of the continuous mixers belong to the gravity type, but the Trump Measuring and Mixing Machine described in this article, is firstly a measuring or proportioning machine and secondly a mixer, turning out concrete either wet or dry continuously, and operated mechanically, and does not utilise gravity for the mixing of the concrete. The power required for this type of machine is very small.

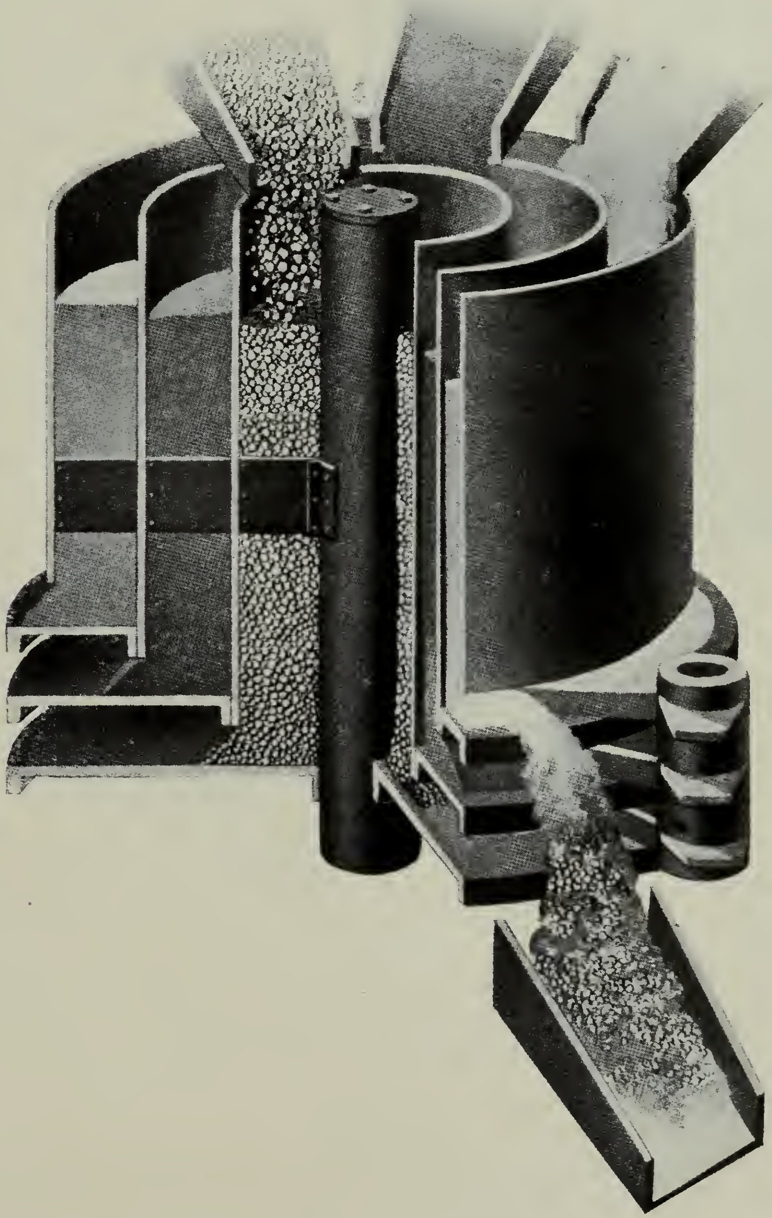
The feeding of the various materials to the mixer proper is performed by a measuring device which consists of three cylinders, into each of which the sand, ballast, and cement are thrown in bulk, and from which the materials pass to three rotating tables where they meet fixed knife edges that scrape the materials off into a trough below in required proportions.

The quantity scraped off at each rotation can be varied by altering the set of the knife so that any special proportion of the ingredients is automatically secured, and can be locked.

The materials after thus being proportioned flow in the shape of small streams which become mixed as they fall in minute proportions, and thus ensure the most intimate contact of cement with the ballast and sand. After this stage the water is also sprayed in from a perforated pipe, and the materials are thoroughly mixed in a cylinder in which steel paddles revolve on a shaft, the mixer proper being of the usual paddle type.

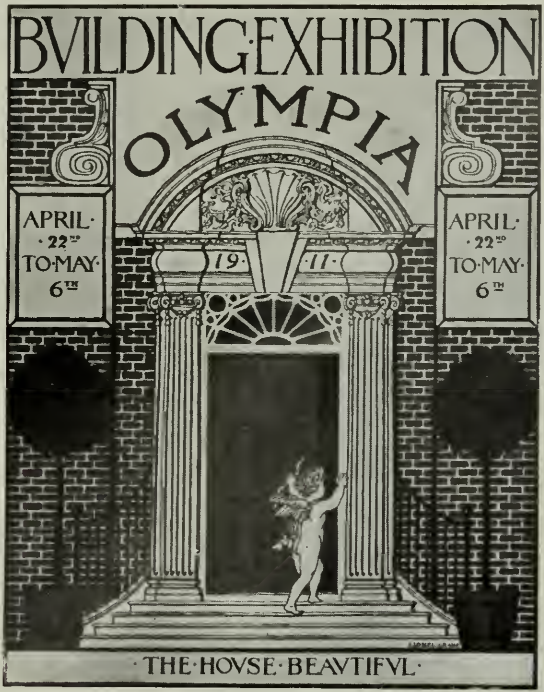
With careful operation much economy may be effected in the mixing of concrete, and a very uniform proportion of the materials can be obtained.

There are several types of machines suitable for various classes of work that are put upon the market by Messrs. W. J. Fraser & Co., where large quantities of material can be utilised and the greatest possible output is required. Thus, for instance, special types of machines are built for laying concrete roads or the concrete under roads. In these machines the measuring and mixing device is raised on



THE "TRUMP" MEASURING AND MIXING MACHINE.

a cart frame which can be drawn by horses along the site, while the materials are supplied to a conveyor belt that can be pushed across the road from side to side so as to apply the materials to any part.



THE BUILDING TRADES EXHIBITION, OLYMPIA.

The Building Trades Exhibition at Olympia which opened its doors last week again does great credit to its organisers and to the building and allied trades, and is certainly one that should not be missed by anyone taking interest in the building and constructional problems of to-day.

We hope to deal further with the exhibits in a subsequent issue.—ED.

INTERVALS of two years, which elapse between one Building Trades Exhibition and another at Olympia, would be far too short to show any great changes in the more settled forms of building, but in regard to concrete and concrete working appliances, one has been able to chronicle a good deal of change in that time. The industry is so young, and one sees so few traces of standardisation as yet, that we were naturally on the look-out for considerable alteration since the exhibition of 1909.

This expectation is partly realised on the present occasion, but one does not find anything startlingly novel, or any difference in method of considerable importance. Progress has been in smaller things, and more in the direction of a gradual shaking down and perfection of earlier types. Like other new industries, after a few years startling inventions are not so frequent, and the many workers seem to settle down to the improvement in detail of a few main types of construction and methods of executing work.

CEMENT.

As regards materials, of first importance is, of course, the cement, and the stand of the ***Associated Portland Cement Manufacturers (1900), Ltd.*** (No. 118, row F), is worthy of the reputation of this firm and its position as the largest English cement producers. The exhibit shows the materials forming cement, at various stages of manufacture, samples of cement ground to various degrees of fineness, and of the company's well-known products, together with their special "Ferrocrete" brand for reinforced concrete construction. A number of testing machines, including crushing machines made at the company's engineering shops from their own design, are exhibited and shown in operation. The hydraulic crushing machine, shown in *Fig.* 1, is for cement and concrete cubes 50 sq. cm. area. The gauge reads up to 50 tons, and gives: (1) tons of total pressure on specimens; (2) tons per sq. ft. on specimens; (3) kilos per sq. cm.; (4) lbs. per sq. in. on specimens. Various standard tests and other tests are being continually conducted for the instruction of those visiting the Exhibition. A quantity of briquettes of various ages, and cubes of various ages and mixtures are being tested for crushing and tensile resistance. Aggregates of different descriptions, both suitable and unsuitable for mixing with Portland cement, are also shown. At this stand they have also on sale copies of that excellent handbook and guide issued by them, entitled "Every-day Uses of Portland Cement," of which they announce a second edition to be published very shortly, and which will be more than double the size of the first edition that appeared only two years ago.

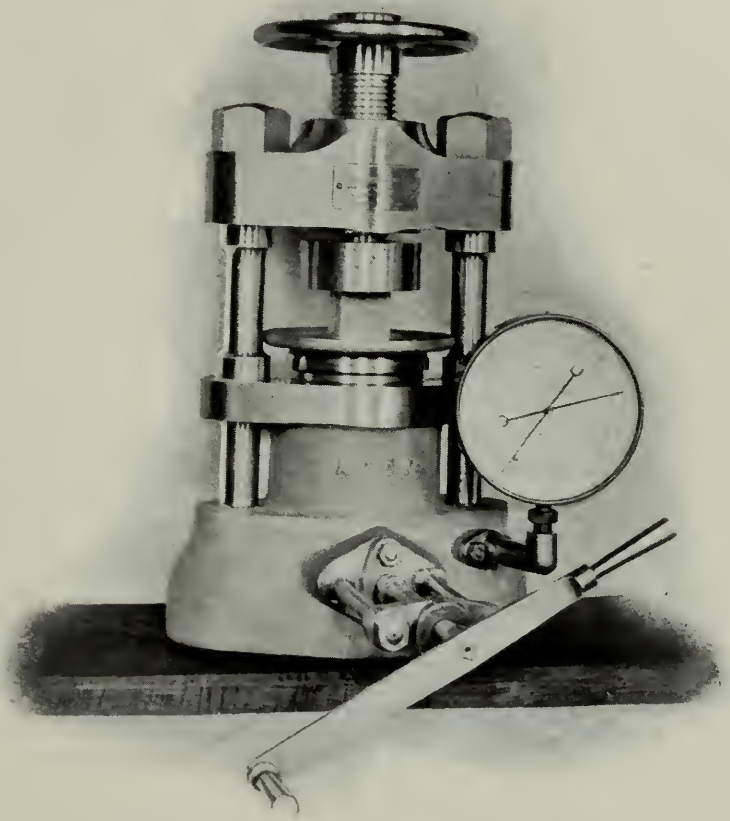


Fig. 1. Hydraulic Crushing Machine made by the Associated Portland Cement Manufacturers.

Messrs. Martin, Earle & Co., Ltd., and ***The Sussex Portland Cement Co., Ltd.,*** are also represented, both of whom are exhibiting samples of their products.

While on the subject of cement, reference may be made to a machine for registering the initial setting time of cement, shown by the ***Ransome ver-Mehr Machinery Co.***

CONCRETE MACHINERY.

Coming to appliances that treat the materials before they are made into concrete or reinforced concrete, we notice that the ***Ransome ver-Mehr Machinery Co.*** (Stand No. 212, row K), exhibit screens for separating and grading sand and aggregate. The screens are horizontal, and not of the rotating type; they are worked by hand, being specially mounted so as to require the expenditure of very little effort. The screen is raised above the ground so as to discharge the materials into skips or trucks below.

Ordinary contractors' vertical screens and rules for levelling concrete floors, etc. are exhibited by ***Messrs. John Yates & Co., Ltd.***

A sand and aggregate washer of a rotatory horizontal type is shown by the ***Builders***

and Contractors Plant, Ltd. Washing of the materials is a very important item to secure good concrete, and the slight expense entailed on a washer of this kind should lead to increased washing of materials, which would improve practice very considerably, and enable higher stresses to be allowed for in the design.

For bending the rods that are used in reinforced concrete work, extravagant means are often adopted, rods of comparatively small section being sometimes heated and worked by a blacksmith, whereas they could be bent cold at a very much smaller cost, and much better, too, by means of a machine. One of these which has been considerably favoured for this class of work is the ***Kennedy Bending Machine*** (Stand No. 34A, row C), which is made in various sizes to bend rods of small or large section. The bends are often required to be quite sharp and at right angles, and hooks have to be bent sharp round to a radius equal almost to that of the bar itself—the Kennedy machine has been specially designed to meet such requirements.

CONCRETE MIXERS.

Passing on to concrete mixers, we do not see any new type displayed, those shown consisting either of the rotating closed box or the open pan and the open trough with paddles. To the former type belong the Ransome, Smith, and the Roll mixers. In the ***Smith Machine*** (Stand No. 33, row C), and the ***Roll Machine*** the box consists of a double cone which can be revolved on its axis to discharge the material at one side ; in the ***Ransome***, on the other hand, the rotating box is a short cylinder with blades to mix the materials, and the discharge is effected by means of a shoot. The Roll is a new mixer for this country, but in both the Smith and Ransome mixers the past two years have seen an improvement in details which has increased the value of the machines to contractors. The ***Express Mixer***, made by the U.K. Winget Concrete Machine Co. (Stand No. 187, row J), is of the open circular pan type, with blades to mix the materials, the discharge being effected by the opening of doors in the bottom. This is a simple contrivance, and a special feature is made of its low first cost. Where mechanical power is not available, machine mixing is still desirable, and attempts have been made from time to time to perfect small machines worked by hand power. The latest is the ***Ransome*** (Stand No. 212, row K), an illustration of which is shown in *Fig.* 2, which is of 2 cu. ft. capacity. This mixer belongs to the open box with paddles type, the concrete being mixed by means of paddles which are set at an angle to ensure the material being always delivered to the centre of the drum, so that the batch is mixed not only longitudinally, but laterally as well. The trouble with the paddle mixers is that stones may jamb between the paddles and the drum. This is avoided in the Ransome machine by the provision of springs which allow the paddles to give sufficiently to clear a stone. The shaft is geared in such a manner that one man can easily revolve the paddles when the full batch is in the drum which has been specially designed in shape for discharging the mixed contents into an ordinary wheelbarrow, the discharge being effected by tilting the drum practically upside down above the barrow. A neat device

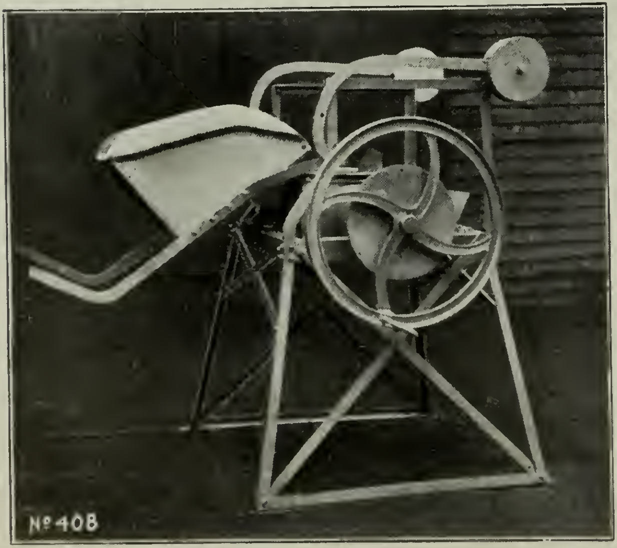


Fig. 2. The "Ransome" Hand Mixer

in connection with this mixer is the feed-hopper, which acts as a measuring skip, provision being made for striking off when exactly 2 cu. ft. of materials has been fed into it. An illustration of this self-discharging skip is shown in *Fig.* 3.

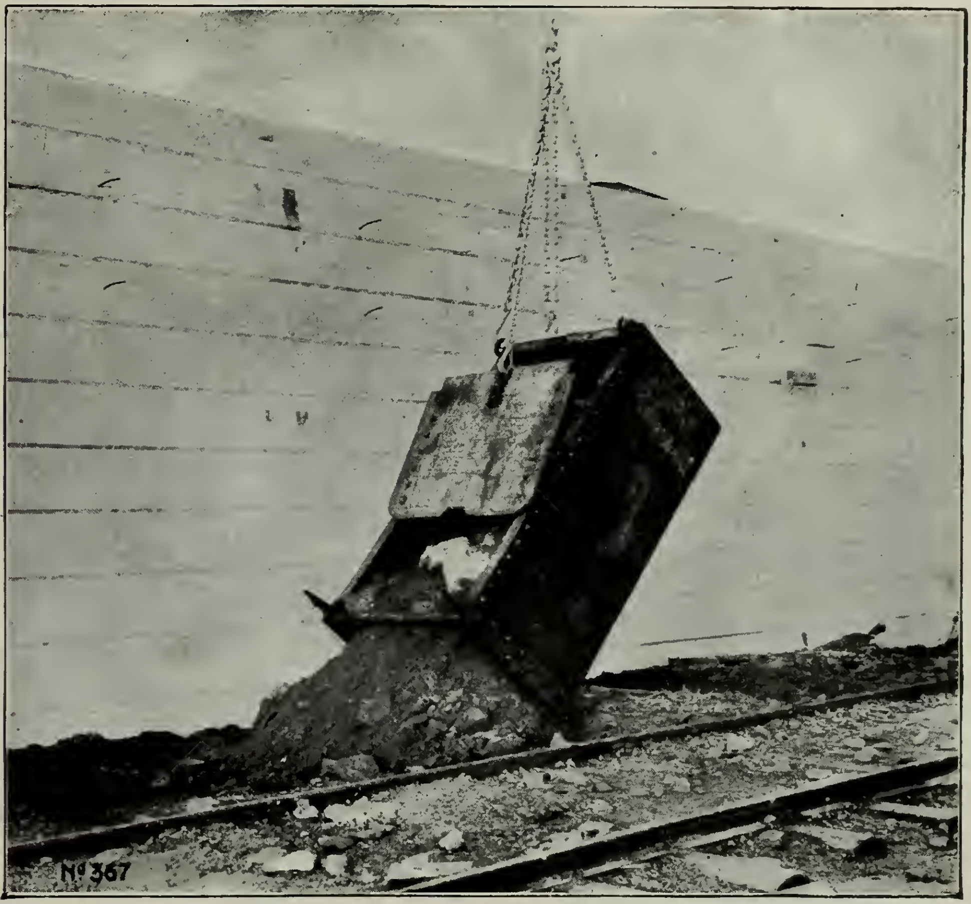


Fig 3.—Self-Discharging Skip of the Ransome Hand Mixer

We notice that ***Messrs. Stothert & Pitt*** also show a cylindrical power mixer of similar type in addition to their Smith mixer.

The Roll Mixer, which is shown by ***Builders and Contractors Plant, Ltd.***, is shaped more like an apple, and consequently is intermediate in form between the double cone and the cylindrical drum. It does not have internal blades to churn the materials, but gives efficient mixing without.

Messrs. F. Johnson & Co. show a mixer of a different type, consisting of a cylinder in which paddles or blades revolve and churn up the ingredients. The trough is open, and one can easily see when the materials are properly mixed, by inspection.

WATERPROOFING MATERIALS.

While on the subject of the making of concrete, its waterproofing is a point to be considered, and the "***Solita***" Cement is a material, in powder form, which is advocated for admixture with the concrete to serve to fill the voids, and give greater density with a view to increasing its waterproofness. Another waterproofing preparation, but in paste form, is "***Ceresit,***" shown at Stand No. 23, Gallery. It is claimed that "Ceresit," used as is ordinary water in the mixing of cement or concrete, makes the latter completely proof against the penetration of moisture or water even under pressure. The water in which the "Ceresit" is placed mixes just as easily with the cement as ordinary water.

CONCRETE BLOCK-MAKING MACHINERY.

As regards concrete block-making machines, the ***Winget*** (Stand No. 187, row J) is a type which has been extensively used. It possesses the novel feature that one movement of the lever opens or closes the mould ; thus there are no loose pieces, and the machine is very quick in operation, it being possible to turn out a large number of blocks in a day. In addition to the Express mixer above referred to, at this stand is shown an ordinary Winget block machine, a special machine for making corner blocks, and a machine arranged to mould six partition slabs at one operation.

Messrs. F. Johnson & Co. (Hull), Ltd., show a concrete block machine, in which pressure is used to densify the materials, in which the cores that form the hollows in the block are separate. **Messrs. Sam Deards, Ltd.,** are showing the Smales concrete block-making machine, and **Messrs. John Pickles & Co., Ltd.,** show small and large block machines.

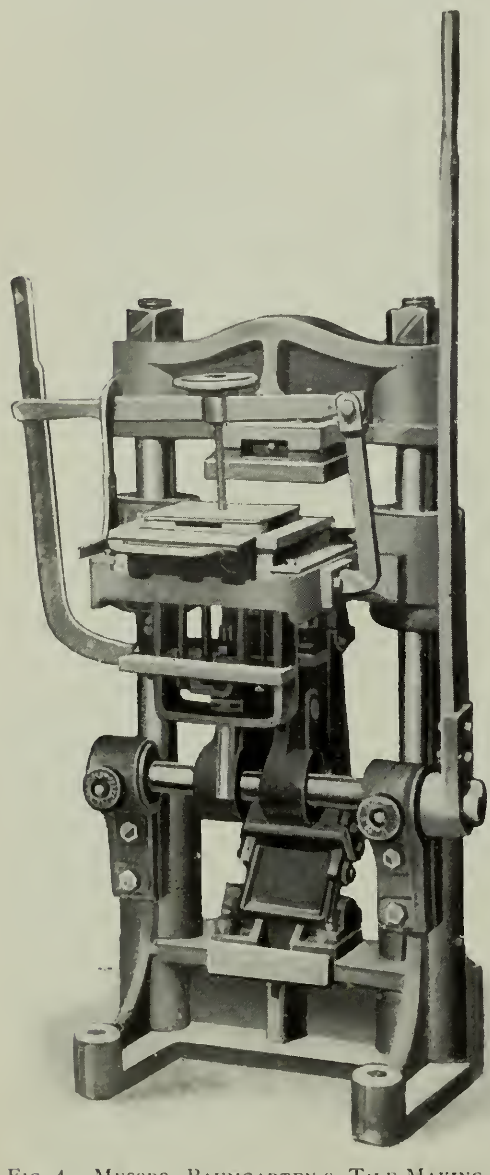


Fig. 4.—Messrs. Baumgarten's Tile-Making Machine.

The First Cottbus Cement Goods and Machine Works, Messrs. Baumgarten (Stand No. 66, row D), show several moulding machines for concrete. There is the concrete brick machine, "Lausitz II.," which turns out six dense, sharp-edged concrete bricks at a time. Plain, hollow, moulded, key-bricks, or paving slabs can be made on it. Another machine exhibited at this stand makes concrete roofing tiles ; these can be glazed in any colour desired. A third is for paving tiles ; a fourth, a hand-press "Hercules," for making concrete mosaic tiles in many elaborate designs and patterns. There is also a machine for making concrete partition slabs. All these emphasise the possibilities in these several directions for developing profitable business in concrete.

PARTITION SLABS.

The subject of block machines naturally leads to partition slabs which are often moulded in somewhat similar machines. In particular, the **Muribloc Partition** (Stand No. 89, row E) is noteworthy, because it is rather differently moulded from the ordinary partition slab, being made in a special machine which affords hollows in the slab, whereas most slabs are made solid. **Messrs. J. A. King & Co.** show their Mack partition slabs, which are made of plaster with embedded reeds, and concrete slabs are also shown. **Messrs. F. Jones & Co.** also show concrete partition slabs.

In connection with partition slabs, we may mention reinforced block partitions which are in evidence at the Exhibition—namely, the exhibit of **Messrs. H. W. Cullum & Co.**

The **Kleine Patent Flooring Syndicate** (Stand No. 117, row F) show a hollow partition constructed with blocks reinforced through with horizontal layers of hoop iron placed alternately near both outside edges of the wall.

Messrs. Richard Johnson, Clapham & Morris (Stand No. 169, row H) show a wall constructed with bricks on edge, and also 4½ in. brick walls reinforced in the joints horizontally with their well-known H.B. reinforcement.

ROOFING TILES, Etc.

Connected with the subject of partition slabs is the asbestos thin slab and roofing tile, made with Portland cement, samples of which are to be found exhibited by the ***British Uralite Co.*** (Stand No. 87, row E), ***Calmon Asbestos & Rubber Works, Bell's United Asbestos Co.'s*** "Poilite" brand, ***Machin & Konig*** and ***G. R. Speaker & Co.'s*** "Eternit" brand. In addition to the asbestos variety, concrete roofing tiles are shown at the Exhibition, and ***Messrs. Sharp, Jones & Co.*** are exhibiting some of these, the manufacture of which is one of their specialities.

Such waterproof covering for roofs lead us to next consider waterproof sheeting for concrete roofs, water tanks, etc. The well-known ***"Ruberoid,"*** which has been used for a good many years now, is shown at Stand No. 151, row G, and the ***Barrett Manufacturing Co.'s*** "Congo" roofings, which have a world-wide reputation, are shown at Messrs. Bristowe's Stand No. 12 in the Gallery. ***"Genasco"*** is exhibited, also ***Callender's*** special material. ***"Vulcanite,"*** which, while consisting of material applied in the form of sheets, gives a much thicker roofing than the foregoing, is shown at Stand No. 104, row E. These materials, of course, each have their special advantages.

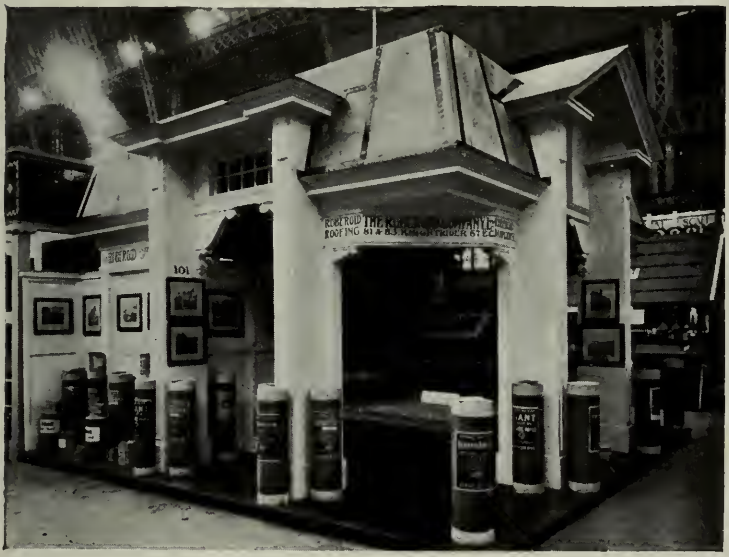


Fig. 5.– The Ruberoid Company's Stand.

Limmer Asphalt, Leyssel Asphalt, and Trinidad Asphalt are, of course, applied hot, as a plaster to concrete roofs, etc.

While we are still connected with the subject of moulded concrete, reference may be made to the exhibit of some large reinforced concrete pipes by ***Messrs. Sharp, Jones & Co.***; to ***Messrs. Hubert Todd & Co.'s*** exhibit of finely moulded decorative artificial stone, and to a similar exhibit by the ***Empire Stone Co.*** (Stand No. 21, row B).

FLOORS.

The Empire Stone Co. also exhibit the Seigwart reinforced concrete floor, a special point of which is that the hollow concrete tubular beams are cast a number at a time all in one operation, joined together as one block, and are there and then sawn up into separate beams by a special saw.

Another moulded reinforced concrete floor is the ***Armoured Tubular*** (Stand No. 213, row K). In this case, however, small hollow blocks of coke breeze concrete are dropped between solid reinforced concrete ribs (the concrete being of superior quality), and a top finish of concrete is applied over all to give the compressive resistance necessary for strength. Sections of their flooring are shown, which are applicable up to clear spans of 30 ft., as well as a variety of methods for finishing the upper and lower surfaces of such flooring. The formation of floor trenches and the method of trimming for lift and other openings in floors are also explained at this stand.

As regards floors with a level ceiling (of which the Seigwart and the Armoured Tubular are examples), we find ***Messrs, Homan & Rodgers*** floor, which was invented a good many years ago and has been employed extensively,on view at Stand No. 127, row F.

Messrs. Kleine Fire-Resisting Flooring Syndicate, Ltd., at Stand No. 117, row F show their well-known hollow brick floor, which has round or flat rods placed between the joints, and concrete filling applied on top of the bricks, thus converting it into a reinforced concrete ribbed floor, with a brick ceiling slab between the ribs. A similar floor is shown by ***Messrs. Horace W. Cullum & Co.***

As regards ordinary fireproof floors and roofs, we now, by natural progression, come to the simple flat slab of reinforced concrete. ***Messrs. Homan & Rodgers*** show this in its plainest form at their stand, where a floor is on view with rods carried between rolled steel joists which serve as the main beams. ***The Expanded Metal Co., Ltd.,*** at Stand No. 156, row G, show the application of their well-known product to the reinforcing of similar slabs.

The Trussed Concrete Steel Co. (Stand No. 153, row G) are showing a new product, "Hyrib," which is intended to serve as a reinforcement as well as a permanent centering, it being claimed that there is considerable economy in this saving of timber centering effected by employing this perforated and distended steel sheet, the cost of the material comparing favourably with the cost of the timber false work. An illustration of this "Hyrib" is shown in *Fig.* 6. At this stand the Trussed Concrete Steel Co. show a floor slab under test load, a partition, and three systems of casting concrete slab between rolled steel joists for flooring, in all of which "Hyrib" is used.

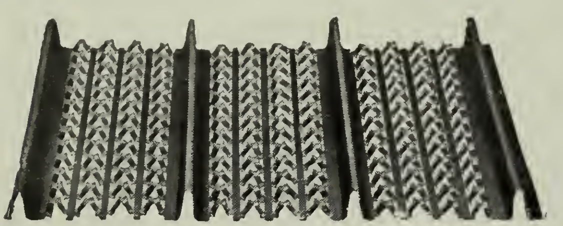


FIG. 6. "HYRIB" REINFORCEMENT.

Messrs. Richard Johnson, Clapham & Morris (Stand No. 169, row H) exhibit their wire meshwork reinforcement for floors. At this stand a continuous concrete floor has been erected, resting on beams 6 ft. apart, and having one bay, only partly concreted, thus showing the disposition of the reinforcement.

The Coignet system of constructing floor slabs with round rods is shown by the aid of models, photographs, and drawings at Stand No. 86, row E, while ***Messrs. Leslie & Co.'s*** way of constructing similar slab floors is explained at Stand No. 218, row K.

BARS FOR REINFORCING FLOOR SLABS, BEAMS, Etc.

As regards special bars used for reinforcing floor slabs, the Kahn bar is shown by the ***Trussed Concrete Steel Co.*** at Stand No. 153, where, however, its more extensive application in reinforced concrete beams is more emphasised, and a new bar, called ***"Tenet,"*** which is put on the market by the Combined Concrete Construction Co., is shown at Mr. Kennedy's Stand (No. 34a, row C), as an example of the capabilities of his bending machine.

In connection with the reinforcement of beams, we see that the last two years has led to a better understanding of the manner in which beams should be reinforced against shear or diagonal tension, and the advantage of having the vertical members securely fixed to the main horizontal tension member—as the fangs of the Kahn bar are—have become better appreciated. The importance also of having a hook or other device to develop the tension in the short length of vertical members is becoming recognised, as evidenced by the Leslie linked system, in which the shear members are clamped to the main bar by the wedging action of a driven-on link. In the Richard Johnson ***"Keedon"*** stirrup, shown in *Fig.* 7, in which the member is wedged against the bar, and in the Coignet system, where the main bars are cranked up and bent over at the top to engage the top bar, and in the new Expanded Metal bar, where the

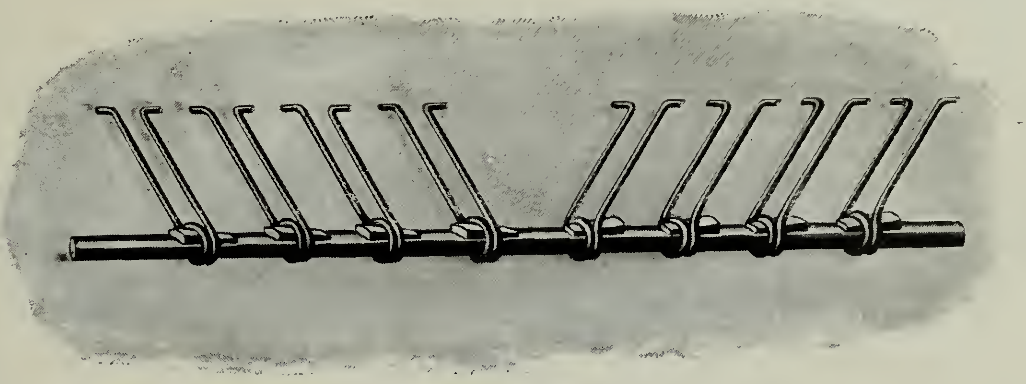


Fig 7.—Johnson, Clapham & Morris's "Keedon" Stirrup.

mesh of the expanded metal sheet attached to the square section main bar serves a like purpose.

We may mention that the ***Expanded Metal Co.'s*** exhibit, shown in *Fig.* 8, is of reinforced concrete throughout. It comprises full-size examples of reinforced concrete column footings, columns, beams, stairs, floors, arches, and roofs. The method and arrangement of the reinforcement is clearly displayed.

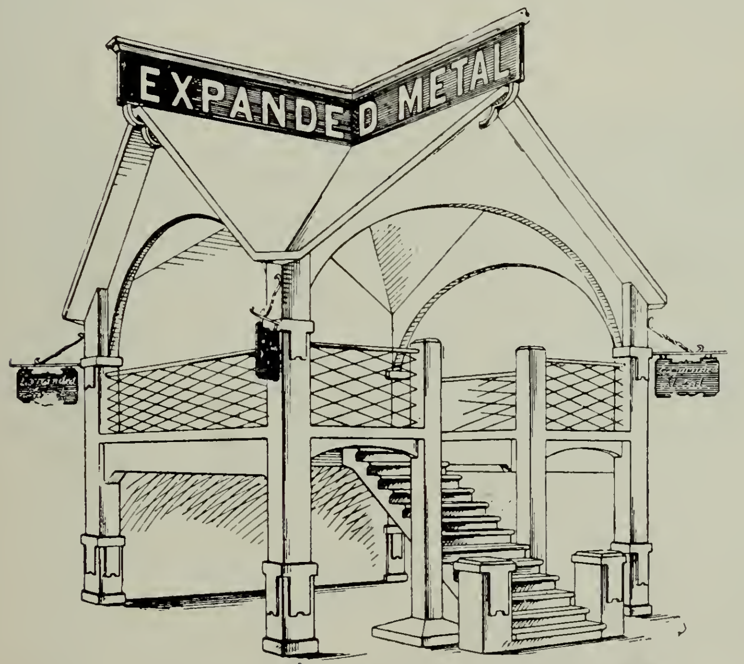


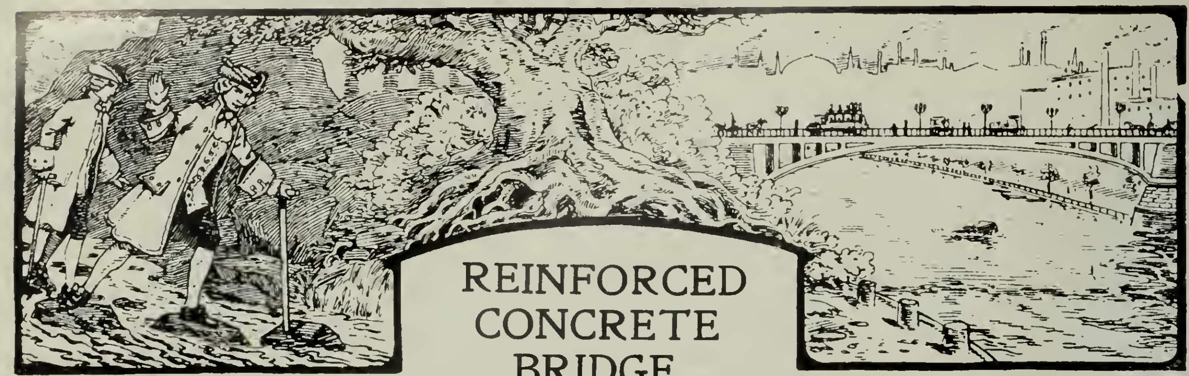
Fig. 8. Expanded Metal Co.'s Exhibit.

There are a good many reinforced concrete specialists who are not in evidence at the Exhibition.

We may say generally, in speaking of the foregoing systems of construction, that all the firms mentioned do, of course, apply their systems of reinforcement to the construction of the very many applications of concrete that are made to-day, as, for instance, to pipes, sewers, arches, reservoirs, columns, etc.

We see, therefore, that the tendency in the last two years has been chiefly in the direction of improvement of detail, either in the making of concrete and the manufacture of concrete articles, or in the detailing of reinforced concrete structural members. There are only two new bars to chronicle—namely, that of the Expanded Metal Co. and the "Tenet" Bar.

It looks as though the next two years will continue this tendency to standardisation, and the concrete will become more in the nature of one of the staple branches of the building trade. But though the industry becomes more staid and commonplace as it grows older, it becomes at the same time of greater importance and wider reach, and as things appear to be shaping, the concrete industry has reason to anticipate continued growth of business and improving trade.

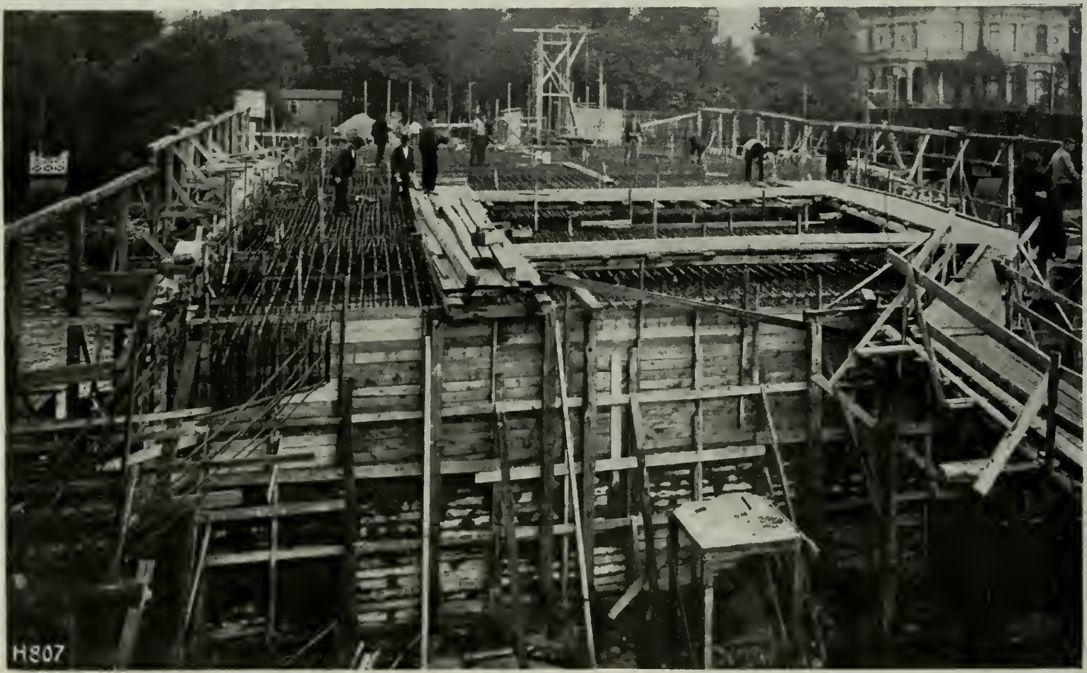


REINFORCED CONCRETE BRIDGE, OVER THE LANGENZUG CANAL, HAMBURG.

The constructional details of the bridge over the Langenzug Canal, Hamburg, are of special interest and should claim attention.—ED.

THIS bridge over the Langenzug Canal, a branch of the Alster, was built to replace an old iron structure, and carries the traffic by a roadway 33 ft. wide, and two footpaths each 10 ft. wide. There are three arches over the canal, the middle one of which is 60 ft. clear span, and is used for pleasure traffic, the two side ones, with spans of 27 ft., being used for barges and other goods traffic.

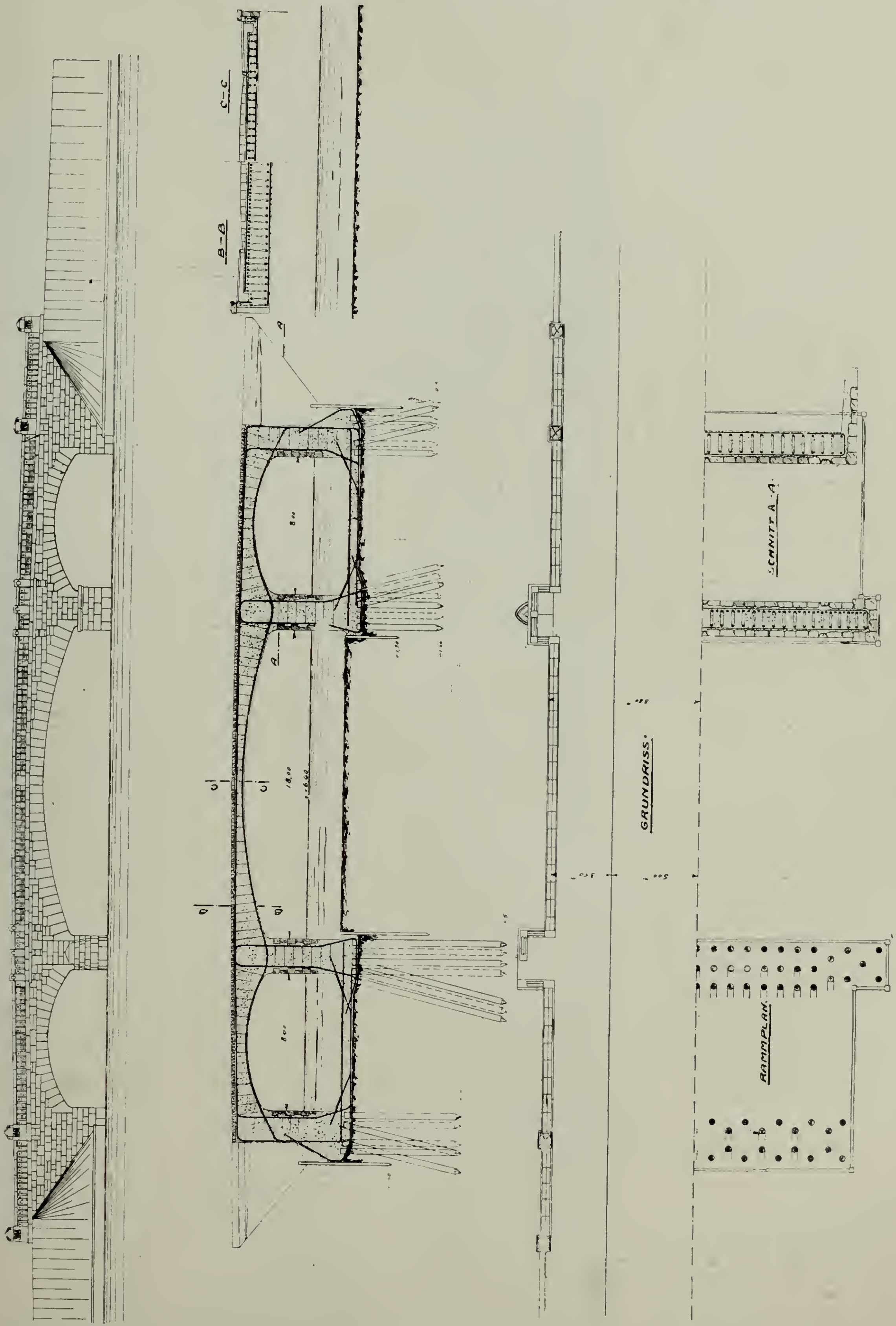
The condition that the road surface must not be higher, nor the intrados of the arch lower than the figures given by the architects, made reinforced concrete the only possible material for the construction, especially as the arch itself was very flat.



View of the Top Reinforcement in the Arches.
REINFORCED CONCRETE BRIDGE OVER THE LANGENZUG CANAL, HAMBURG.

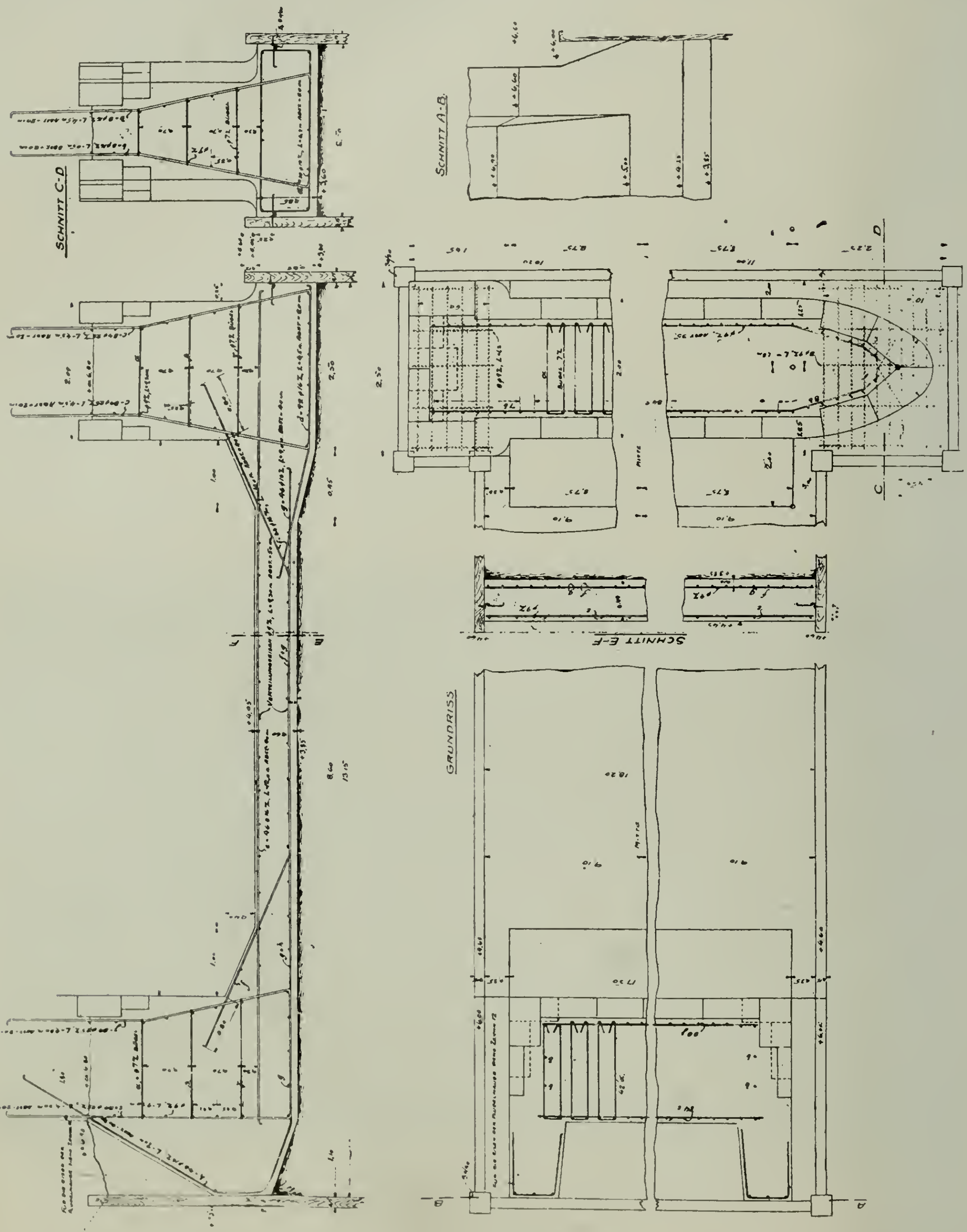
As will be seen from the general arrangement of the bridge, the two smaller arches are designed in a special manner, the intermediate pillars being connected with the abutment pillars by a strong reinforced concrete slab, so that the smaller arches actually form a very stiff and massive abutment for the middle one.

It was deemed necessary to carry the whole structure on piles, and the nature of the soil proved so irregular that this precaution was fully justified, the piles being exceedingly hard to drive on the south side, whereas on the north side especially long piles were required to reach solid ground. The whole of the



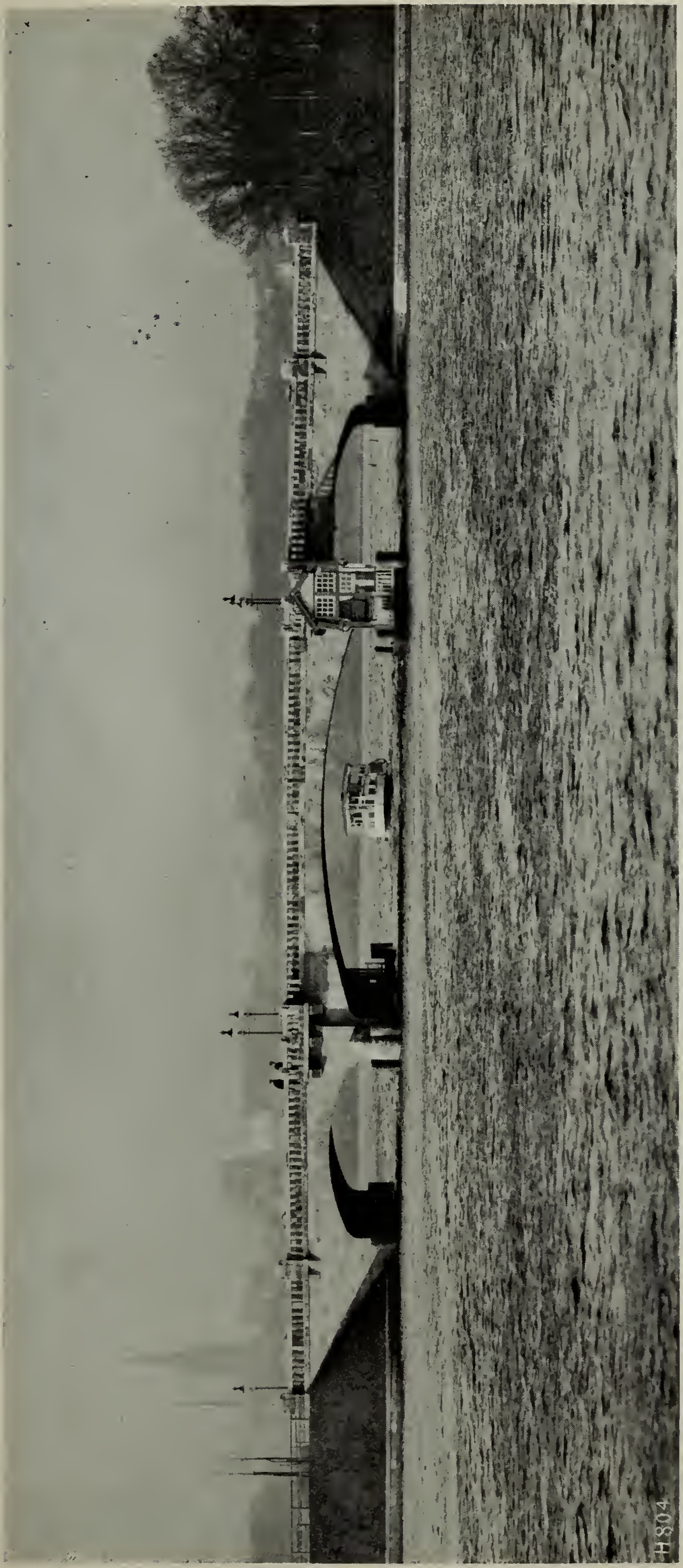
Plan, Sections and Elevations.
Reinforced Concrete Bridge over the Langenzug Canal, Hamburg.

foundation is protected from undermining by sheet-piles, which were used as a dam inside which the excavations for the foundations took place, two 4-in. centrifugal pumps being required to keep the foundation pit dry. The bottom plate was then constructed and the pillars built up to the water-line, after which the scaffolding for the three arches was finished, the middle one being supported on piles driven into the bed of the river, the side ones having uprights standing directly on the bottom plate.



Plans and Sections.
Reinforced Concrete Bridge over the Langenzug Canal, Hamburg.

The pillars, abutments, arches, and wings were then made. Planed boards only were used for the three arches, the under surfaces of which were not treated



View of Finished Bridge.

Reinforced Concrete Bridge over the Langenzug Canal, Hamburg.

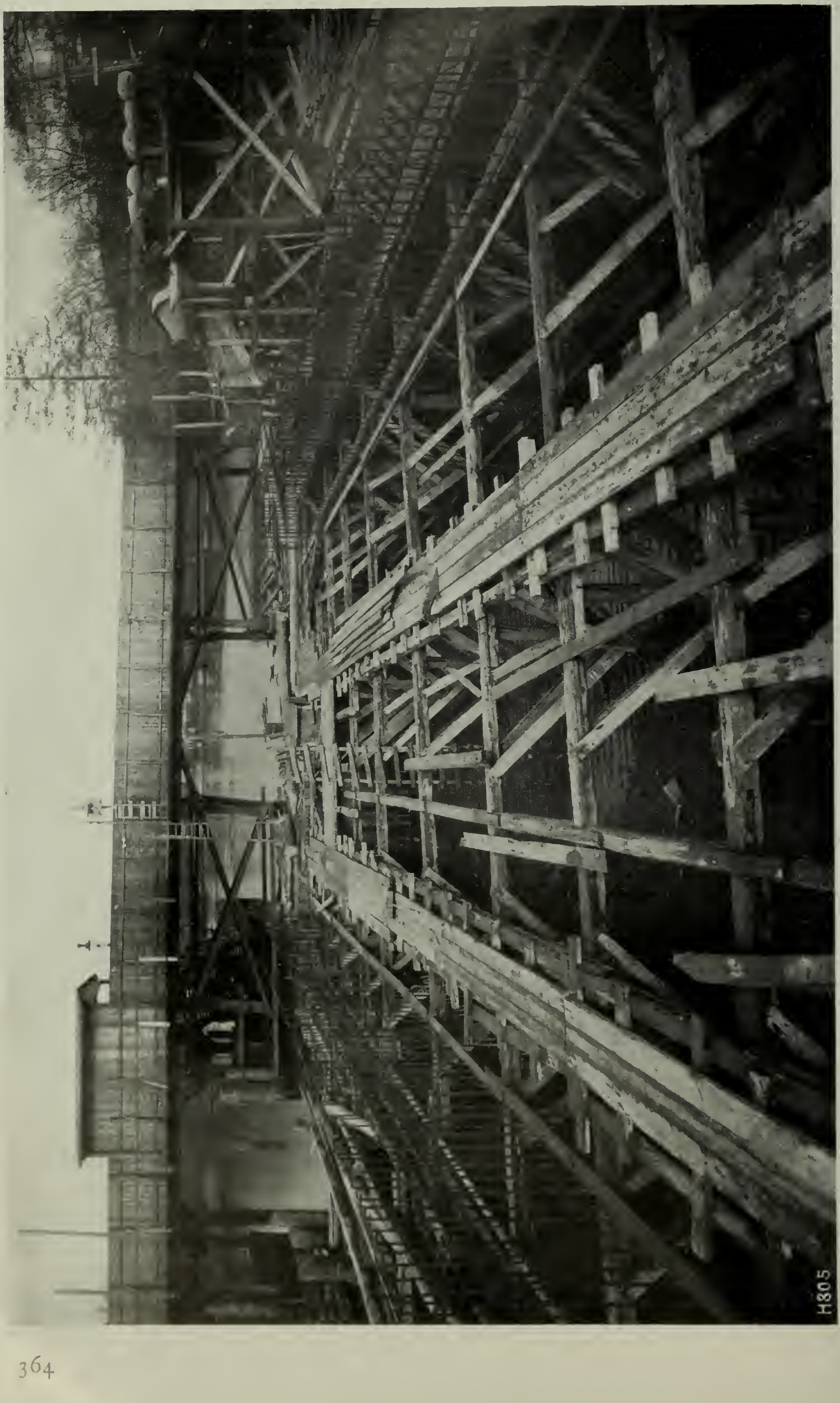
in any special manner, being simply painted with a cement wash. All the other visible parts of the bridge are faced with limestone, the parapets being made of same material.

The wings are hung as cantilevers from the bridge proper, and at the top they are firmly connected with the abutments by means of a triangular beam.

About 70,000 cu. ft. of concrete was used, and the total amount of reinforcement was about 103 tons. The whole of the concrete was mixed mechanically, the mixture being 1 part Portland cement to 8 parts of washed pit gravel in the bottom plates, and 1 cement to 6 parts of aggregate in the pillars and arches.

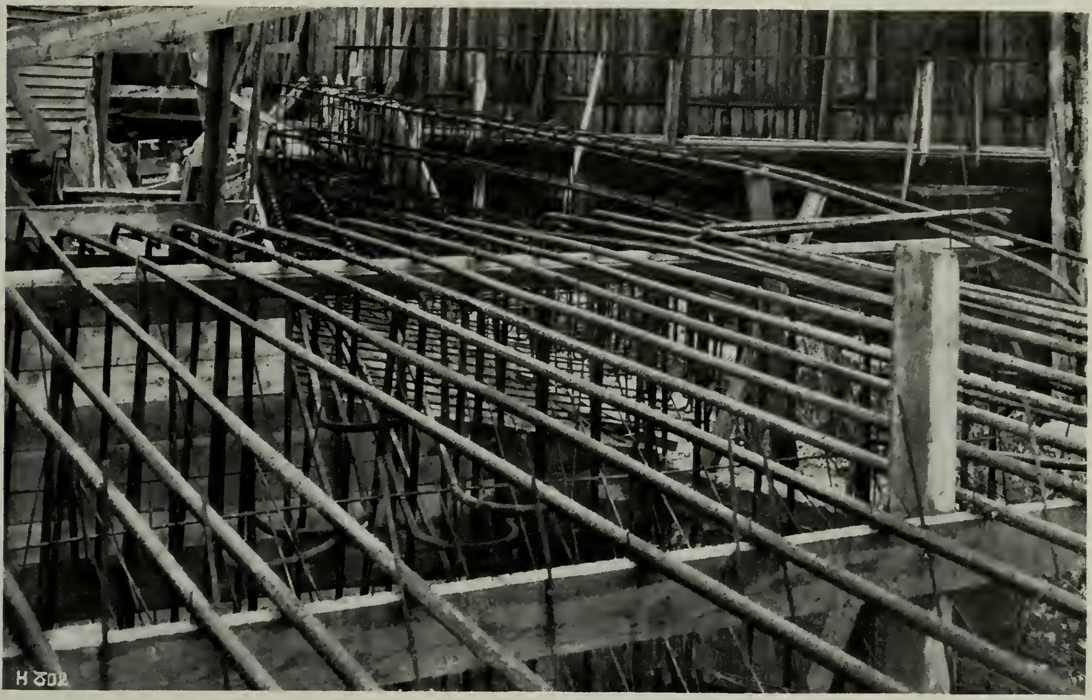
The building of the bridge was completed in the space of about 6 months, and the testing with a

20-ton car was carried out after 28 days of setting. The test was most satisfactory and no measurable deflection was noticed under the load applied.

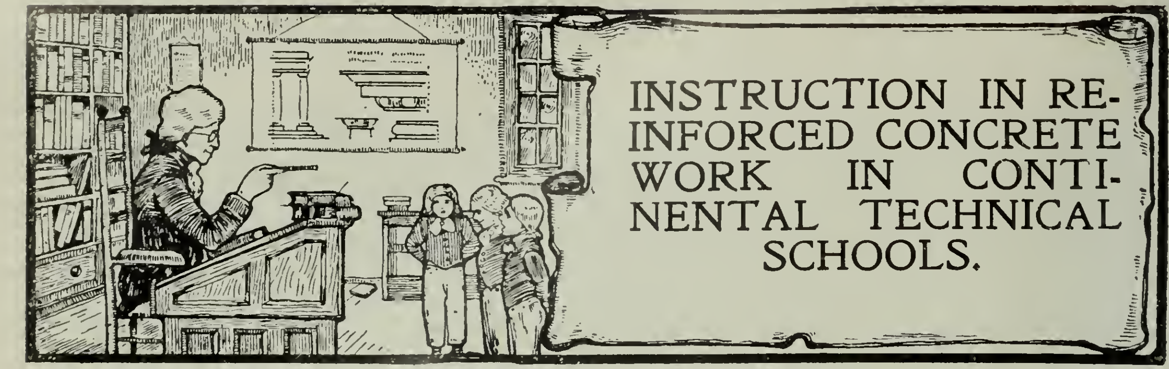


One of the Foundation Pits, showing Reinforcement for Bottom Slab and Pillars.
Reinforced Concrete Bridge over the Langenzug Canal, Hamburg.

The architects for the bridge were the State of Hamburg, and the contract was carried out by Messrs. Christiani and Nielsen, of Hamburg and Copenhagen, who were responsible for the design.



View showing Reinforcement of Arch and Wing.
REINFORCED CONCRETE BRIDGE OVER THE LANGENZUG CANAL, HAMBURG.



INSTRUCTION IN REINFORCED CONCRETE WORK IN CONTINENTAL TECHNICAL SCHOOLS.

The lack of facilities for obtaining instruction regarding reinforced concrete in this country is most regrettable. We are, therefore, presenting an article dealing with the state of affairs in Germany and Austria. Not the least remarkable are the classes arranged for older men, who are already in practice or hold official positions.—Ed.

The reader of current German technical periodicals cannot fail to be struck by the extent to which construction in reinforced concrete has received attention and systematic treatment from members of the architectural and engineering professions in Germany, Austria and Switzerland. The number of publications dealing with the newer forms of construction which emanate from the teaching staffs of the greater technical schools is also very remarkable, and is an indication of the extent to which the subject has received academic recognition. Even the reader who has observed these signs of progress must, however, feel some astonishment on glancing over the lists of courses of systematic instruction in the use of reinforced concrete recently published in *Beton und Eisen*. With the exception of very elementary courses, systematic teaching in building and architecture rarely finds a place in the technical colleges of Great Britain, whilst the newer methods of construction only occasionally form a part of the training of engineers. It is therefore all the more surprising to see how far these methods have already established themselves as a part of the regular curriculum of engineering students in German-speaking countries.

It is not possible to make a direct comparison between the positions there and here, as the relation of the architect and constructional engineer to the builder or contractor is very different from that which obtains in this country, but a review of the provision made for the instruction of those already engaged in industry, as well as for those who are undergoing training as students, is nevertheless of interest.

The tables published in *Beton und Eisen* show that special courses of lectures on reinforced concrete construction, accompanied in many instances by practical work, are given in 19 technical high schools and 42 building-trade schools, whilst 29 other trade schools include the subject in their general courses of statics, engineering, or building construction. The institutions included in the list are distributed over Germany and Austria, with the addition of a few Swiss technical schools, of which the most important is the famous Zürich Polytechnic. The language of the courses enumerated is German, with the exception of that in Lausanne, which is in French, and at Prague and Brünn, where courses are conducted in the Czech language as well as in German.

There are no data as to the total number of students attending these courses, but the fact that 285 students attended the course in reinforced concrete construction at Lemberg, 120 in Charlottenburg, and nearly 300 in Prague during last session, gives some indication of the extension already attained. As an example of the regular training of students, we may select the Technical High School at Dresden, where the following courses are held :

1. A course of 100 lectures in the summer term on reinforced concrete for architects and engineers;
2. A course of 25 practical classes in the winter term;
3. Fifty lectures on the execution of reinforced concrete work, during the summer;
4. Fifty classes in the design of reinforced concrete structures, during the winter. This class includes visits to buildings in course of erection.

In a systematic course of training in building construction, the special study of reinforced concrete is taken up during the student's third year—two hours each week throughout the two terms—in addition to the more general treatment of the subject in the lectures and drawing-office work in building construction and design.

In addition to these special classes, the long winter course on the construction of masonry bridges includes the treatment of reinforced concrete bridges. Similar arrangements, although not always so extensive, are made at most of the other schools, the practical work sometimes including the complete working out of a design for some structure in reinforced concrete. The theory of such structures is sometimes treated as a separate course, or else finds a place in the general courses dealing with the theory of structures. In addition to these classes, which are specially devoted to the subject, it is found necessary to devote a share of attention to reinforced concrete construction in the lectures and practical classes treating of bridge, hydraulic, and railway engineering, of building, and of general statics.

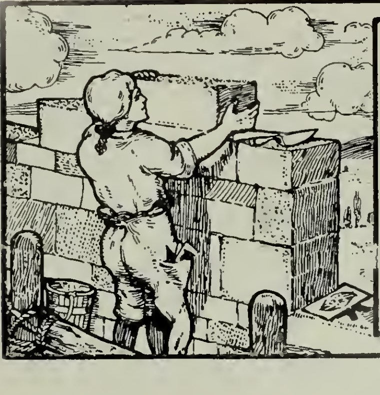
The fact should also be noted that provision is made in several instances for instruction to persons who have ceased to be students, and who are actually engaged in practical work as architects, engineers, surveyors or builders. Classes of this kind are specifically mentioned in the tabular statement as being provided at Hanover, Breslau, Brünn, Chemnitz, Dresden, and Glauchau (Saxony), but it is probable that most of the other courses are open to such persons under certain conditions. The fees charged are small, amounting as a rule to either 20 or 30 shillings for a course extending over one term (about five months). At Chemnitz, the number attending the special lectures during the last session was about 30, comprising architects, builders, and municipal building officials.

The instructors in the trade schools are practical engineers and architects. In the higher technical colleges special professors are provided for each of the main divisions of constructional engineering, and for architecture and statics, whilst the German system of "Privat-dozenten" (semi-independent lecturers who select the subjects of their own courses) gives ample scope for instruction in special branches.

It must be remembered that the professors of technical subjects of this kind are, as a rule, also engaged in practice as designers of buildings of engineering works, and are therefore in close touch with the practical developments of their subject.

At the Royal Technical College, Aachen (Aix-la-Chapelle), reinforced concrete construction has already been made a special branch in which a student may elect to take his diploma.

It is obvious that the recognition thus given by the centres of technical education to the newer methods of construction must be an important factor in contributing to that very general adoption of reinforced concrete which has been so remarkable a feature of recent engineering and building practice in Germany and other Continental countries. It does not follow from the success thus obtained that the German system of provision for systematic instruction should be copied exactly in this country, where the practice of receiving training in a technical college or university, although fairly general among those about to enter the engineering profession, has hardly established itself in connection with either architecture or building, but it is certain that much may be learnt from a study of the teaching referred to. We must attribute to it the closer connection between theory and practice which indisputably characterises German constructional work, and that greater readiness to adopt improved methods based on the theoretical and experimental researches of adequately trained engineers and architects.



THE Y.M.C.A. BUILDING, MANCHESTER.

One of the most important structures that have been erected in this Country in Reinforced Concrete is the new building for the Y.M.C.A., Manchester, details of which are given below. This article was preparea for us by Mr. Albert Lakeman, Hon. Medallist, Construction.—ED.

THIS building is constructed entirely in reinforced concrete, and, like many other buildings of this type, it exhibits some examples of structural design of no mean order, which were evolved in the skilful handling of intricate and unique problems necessitated by the character of the building, which required several large apartments, with a clear floor space, at different levels and points in the building, thus

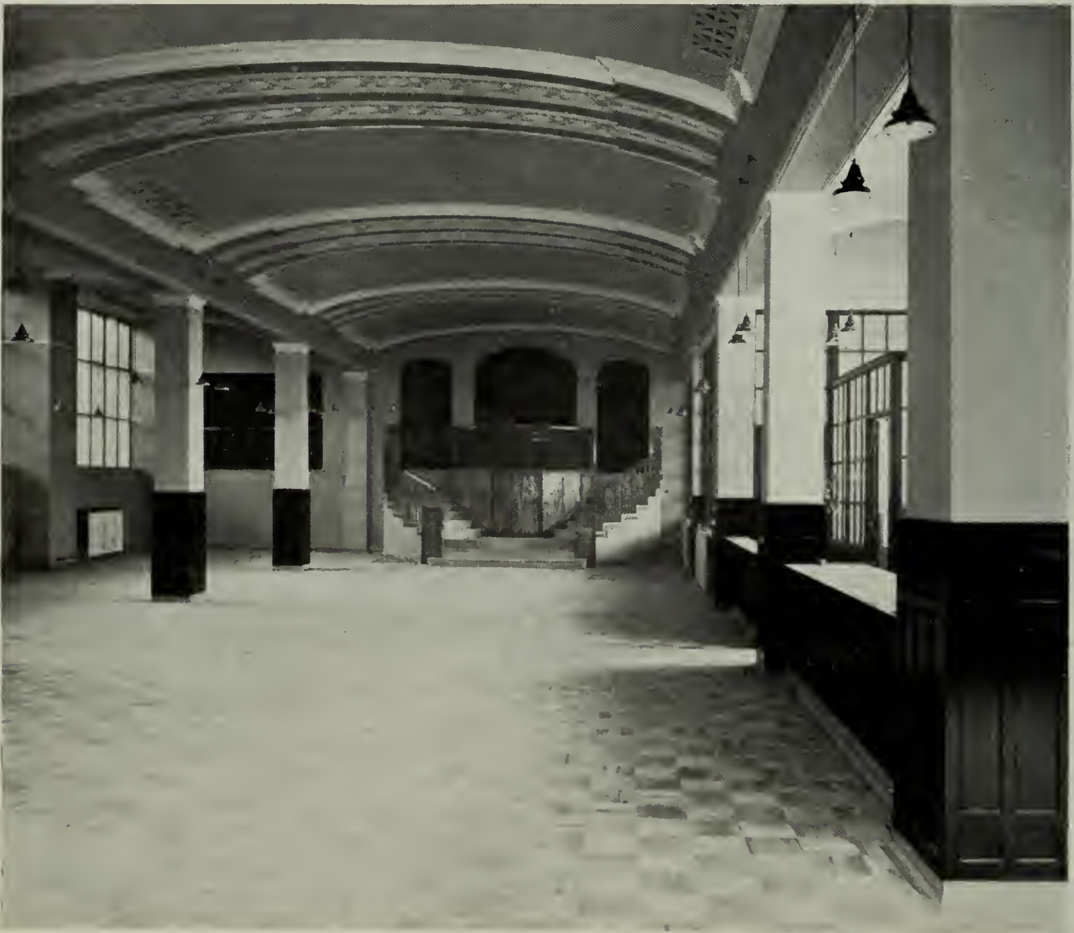


Fig. 1. Interior of Lounge on Ground Floor.
Y.M.C.A. BUILDING, MANCHESTER.

reducing the number of possible continuous vertical supports, and inflicting heavy loads on those available. It is only proposed to describe in detail those features

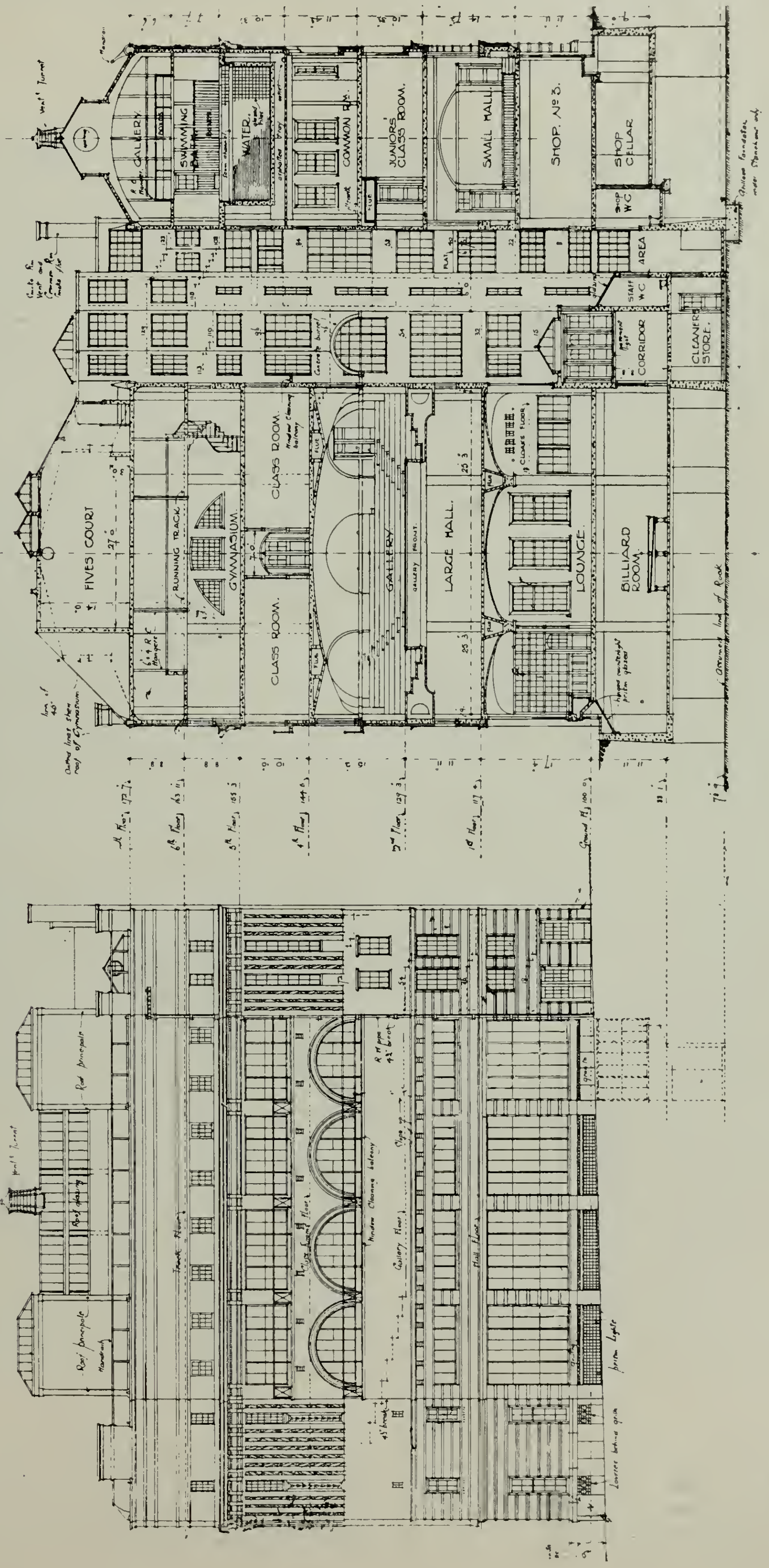


Fig. 2. Elevation and Section.
.M.C.A Building, Manchester.

of special interest, and before proceeding to do this, it will be advisable to indicate the extent and nature of the accommodation provided, in order that the structural difficulties may be fully appreciated.

The position of the building is a central one, it being situated next to the Midland Hotel in Peter Street, with frontages to Mount Street and Museum Street in addition. The site covers an area of about 10,476 sq. ft., with a façade measuring about 108 ft. to Peter Street, and about 97 ft. to Mount Street and Museum Street. The total height from the lowest basement floor to the main roof is about 110 ft., while the height above the street is approximately 75 ft. There is a sub-basement floor, which is occupied by the heating chamber, stoves, and various similar apartments, and this floor is only constructed over a portion

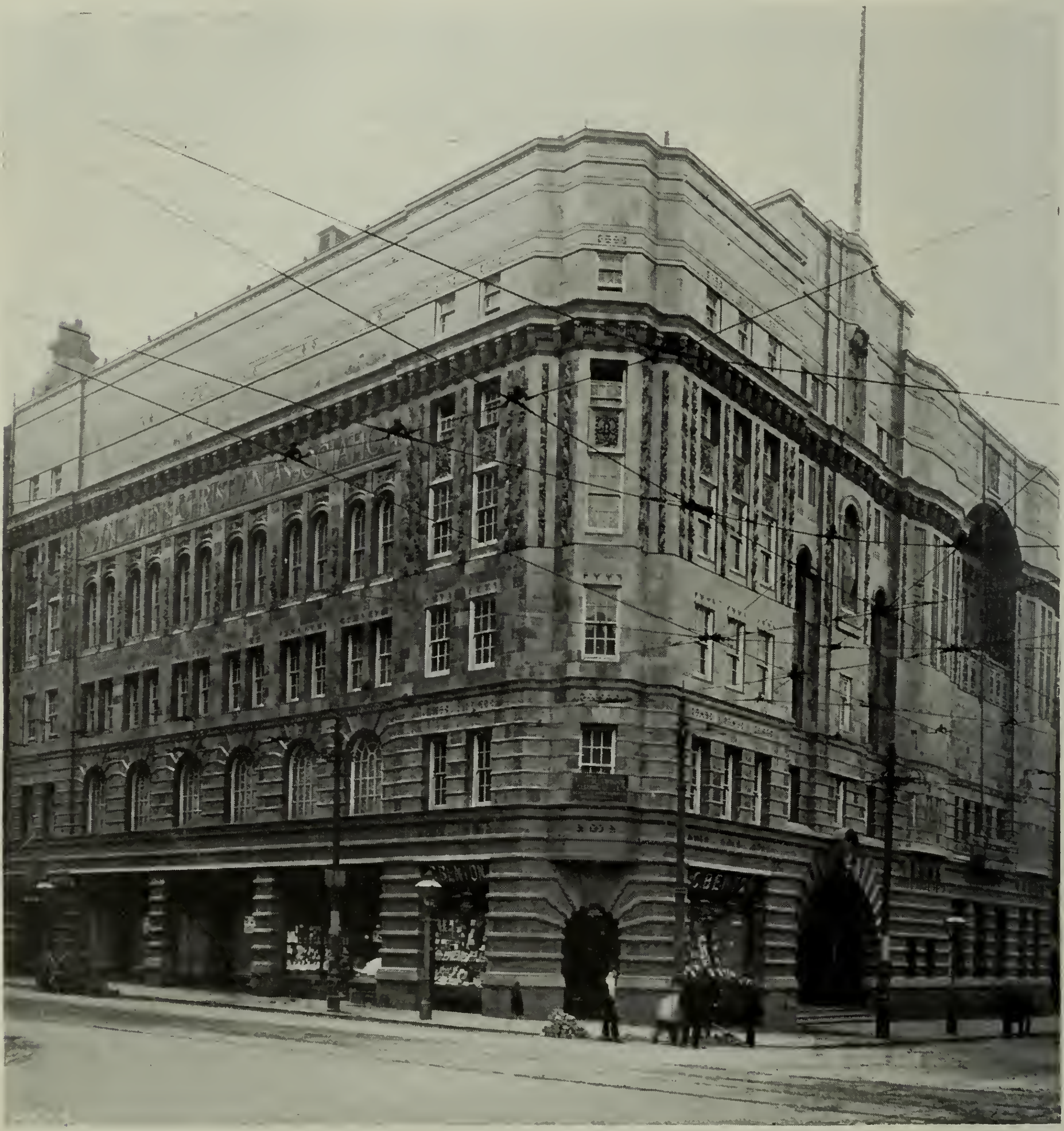


Fig. 3. View of Finished Building.
Y.M.C.A. Building, Manchester.

of the site. The basement floor is chiefly occupied by a members' café, 55 ft. by 44 ft., and a billiard room, 55 ft. by 50 ft., while a smoke room, kitchens and cellars for the shops above are also situated here. Extensive lavatory accommodation is provided on a mezzanine floor constructed between the basement and ground floors. The ground floor is occupied by a large lounge, with a raised dais at one end, suitable for meetings, with entrances in Peter Street and Mount Street, four shops in Mount Street, secretarial and clerks' offices, and the various staircases to the upper part, a separate staircase being provided for

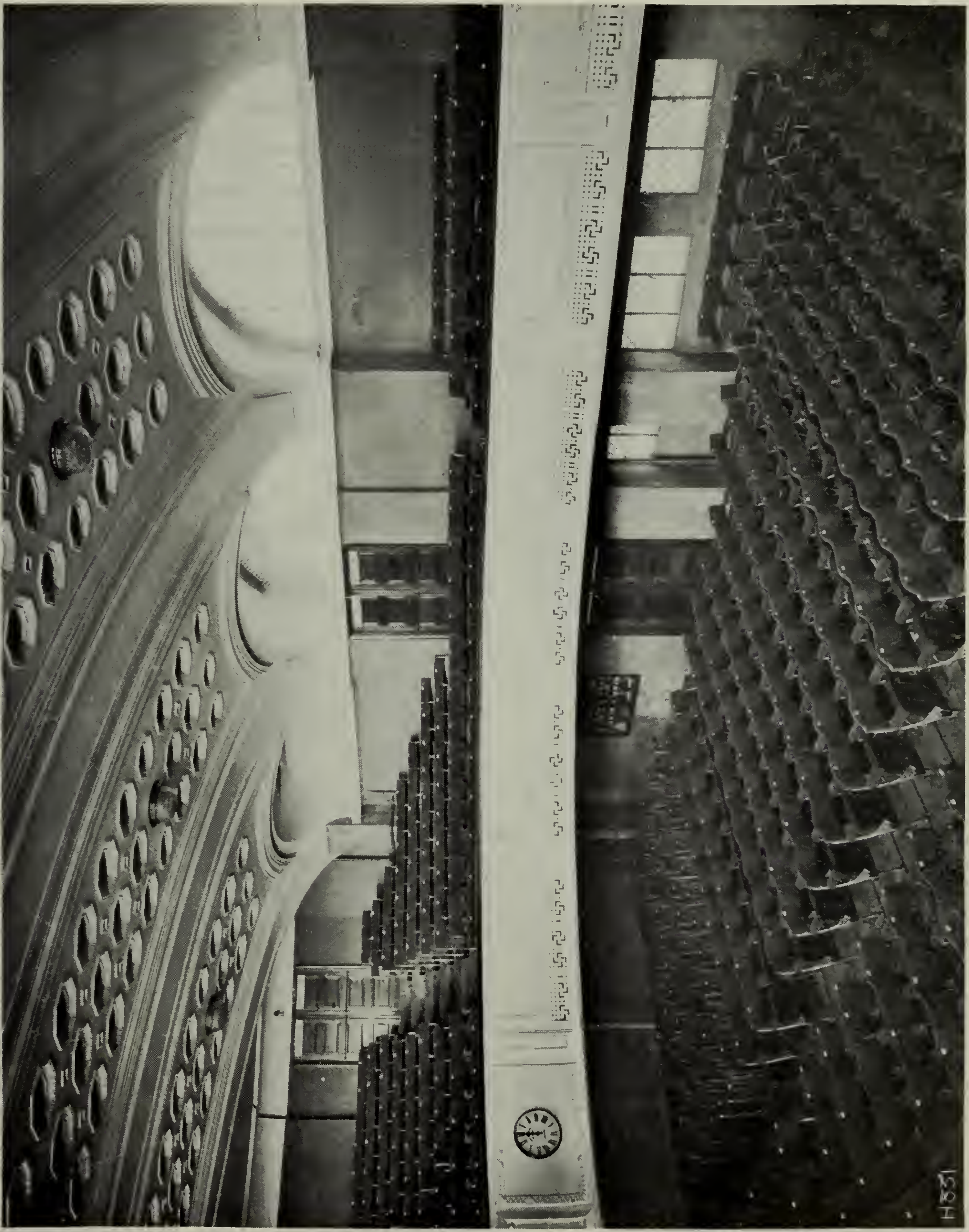


Fig. 4. Interior of Large Hall.
Y.M.C.A. Building, Manchester.

seniors and juniors. The principal apartments on the first floor are the large hall, with gallery above, capable of taking nearly 1,000 persons, and the small

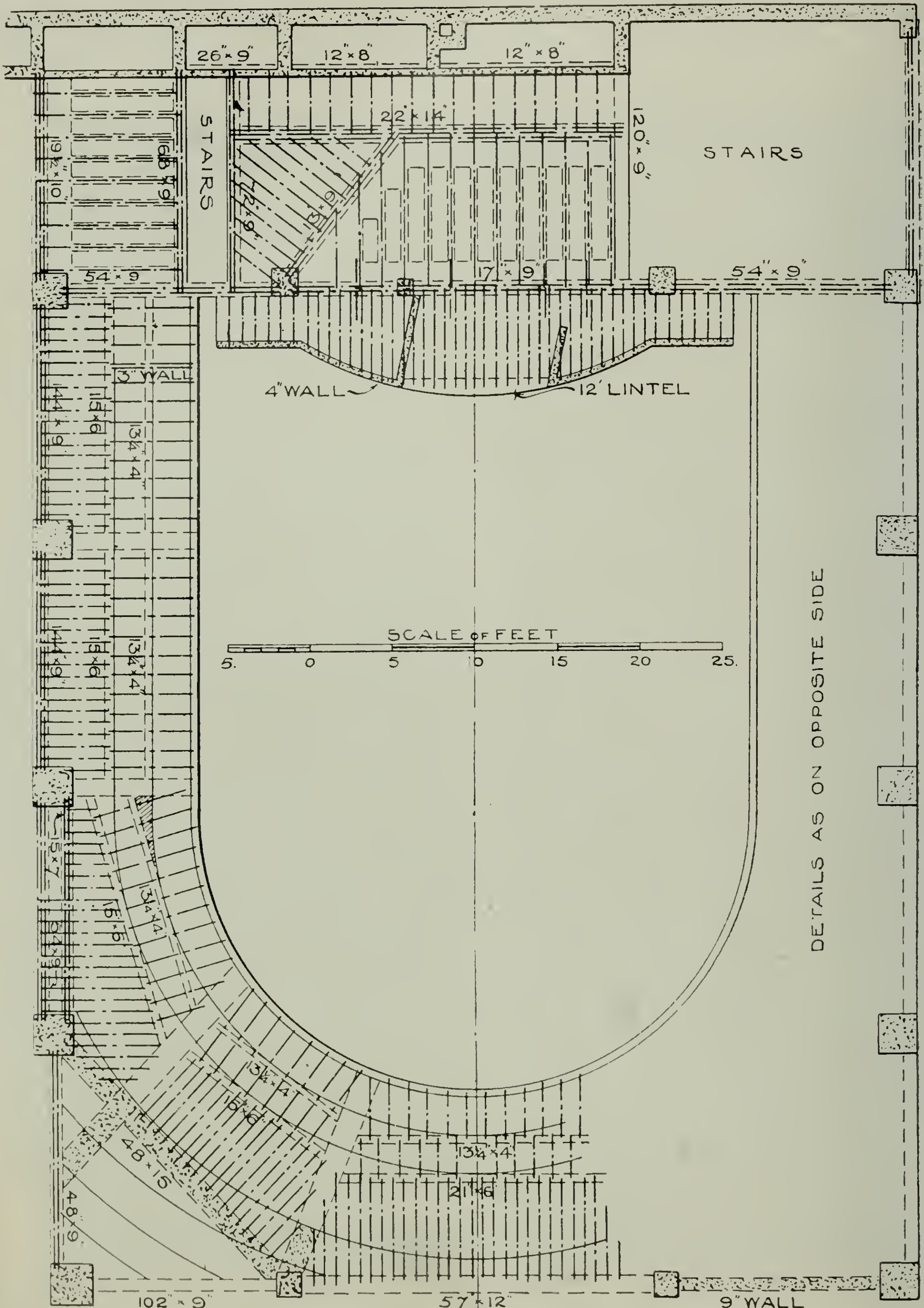


Fig. 5. Plan of Gallery in Large Hall.
Y.M.C.A. Building, Manchester.

hall, with seating accommodation for about 160 persons. In addition there is a library and reading and writing room, with various auxiliary apartments. The large hall is situated immediately over the large lounge on the ground floor, and owing to the height required in the latter, the floor level of this hall is nearly 6 ft. above the general first floor level, and as the height of the hall is nearly 27 ft., it extends right through the second and third floors, thus appropriating a great deal of room. Juniors' class rooms and a hobbies room are provided on the second floor, and a large juniors' common room on the third floor. The fourth floor is chiefly devoted to class and lecture rooms and locker accommodation, while the portion adjoining Mount Street is occupied by the tank of the swimming bath provided on the fifth floor. It is above this point in the building that some of the chief difficulties arose as the fifth, sixth, and seventh floors are planned for the athletic members of the Association.

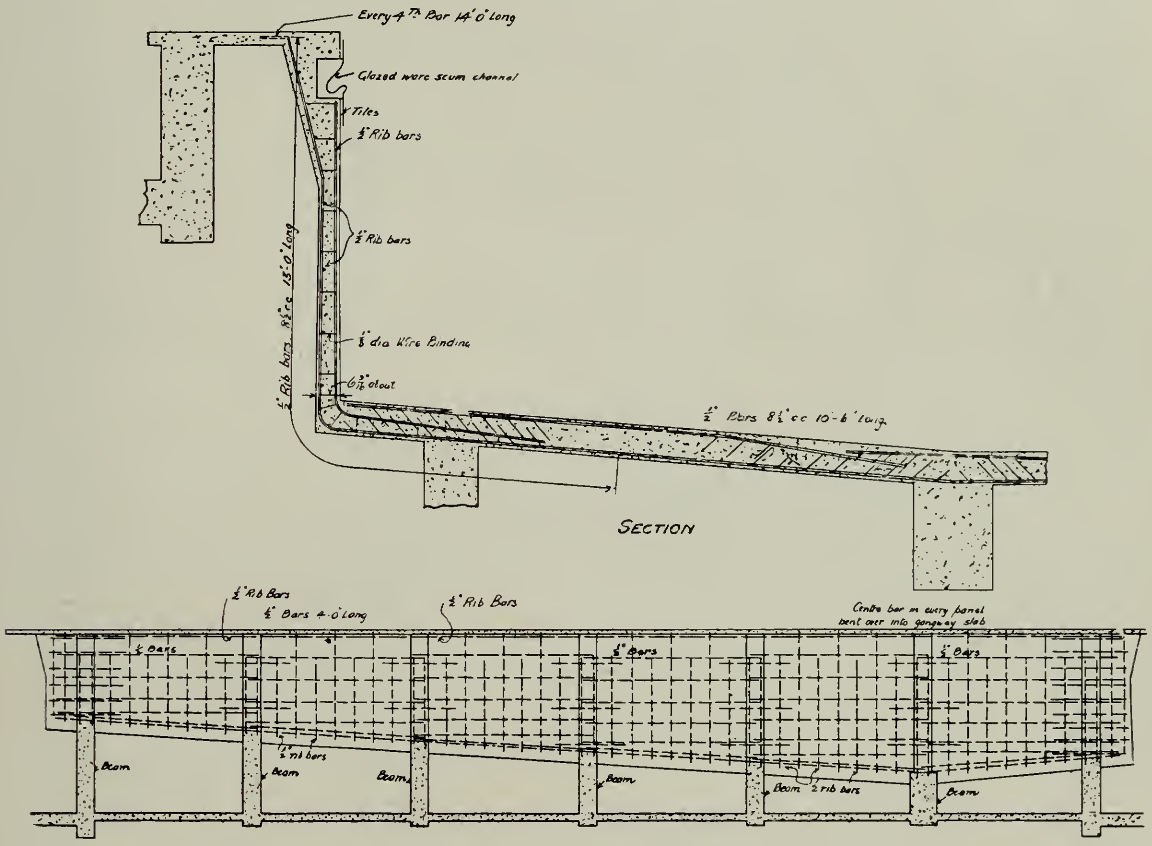


Fig. 6. Details of Swimming Bath.

The accommodation for this athletic association includes a fine gymnasium, over 90 ft. by 52 ft. on the fifth floor, with a running track having 24 laps to the mile immediately above, forming also a gallery to the gymnasium, this track being suspended from the walls of the two fives courts on the seventh floor; these walls also acting as roof principals.

The swimming bath, previously mentioned as being on the fifth floor, is 60 ft. long and 21 ft. wide, and it has a gallery 3 ft. 9 in. wide around same at the sixth floor level. There are also numerous dressing rooms, exercise rooms, instructors' rooms, and lavatories, situated on these upper floors, and the writer is of the opinion that the building forms a unique example in providing a swimming bath and similar accommodation on the upper floors in this manner.

The whole of the structural members are of reinforced concrete, the external walls being faced with terra-cotta, which was carried up and used as a form of shuttering for the structural concrete walls, thus obviating the necessity for timbering on the exterior.

The work to the foundations was formed at different levels, owing to the sub-basement floor only occupying a portion of the site, and the retaining walls surrounding this floor were constructed with 9 in. of concrete reinforced with ½-in. Kahn trussed bars placed vertically at 12-in. centres, and ¾-in. rib-bars horizontally at 24-in. centres, a 2½-in. cavity being formed between this wall and a 4½ brick lining, which was carried up on the inside to prevent any possibility of damp passing through. Generally speaking, the foundations to the reinforced concrete columns were about 7 ft. square, and 2 ft. 6 in. thick, with 1 in. by 3 in. Kahn trussed bars both ways at 9-in. centres. The soil was found to be a red sandstone, having a fairly good carrying capacity.

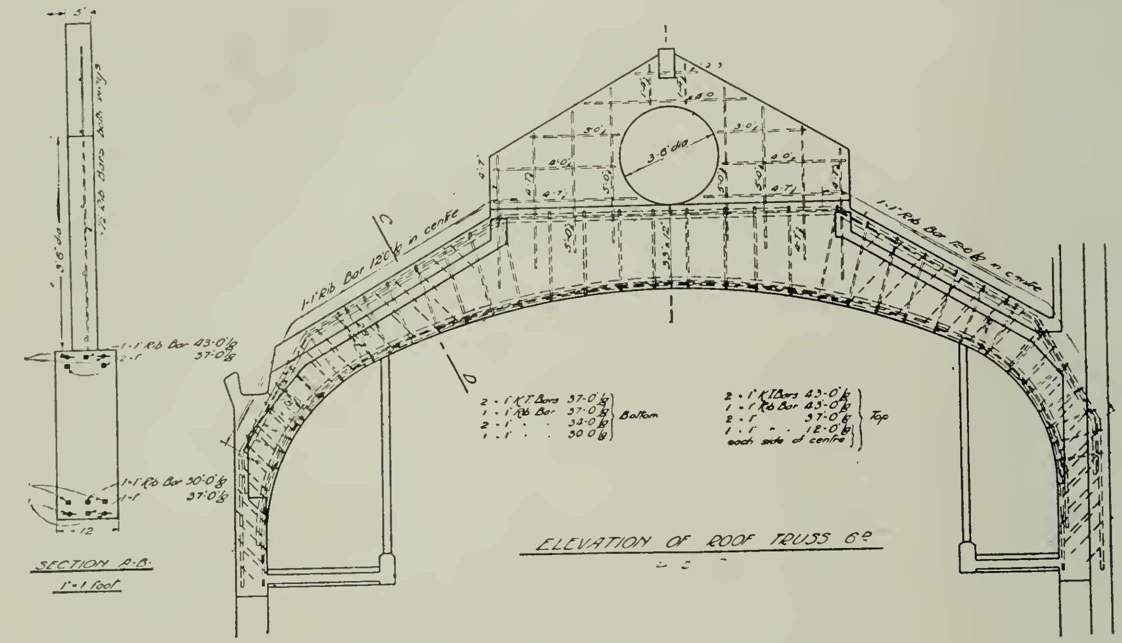


Fig. 7. Elevation of Roof Trusses over Bath.

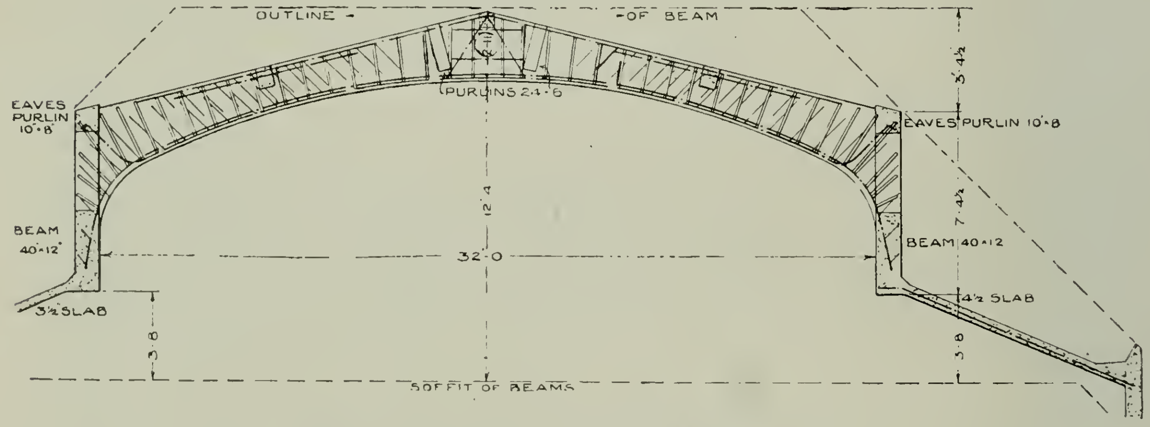


Fig. 8. Details of Roof Trusses over Gymnasium.
Y.M.C.A. Building, Manchester.

The large hall, which is situated on the first floor, provides an interesting feature in the large cantilever gallery, a plan of which is shown in *Fig.* 5. It will be seen that the gallery facing the platform is semi-circular, a plan thus affording a good view from all parts. The outer edge was formed as a deep girder connecting the ends of the cantilevers, and making a monolithic form of construction, the depth being obtained by carrying up the reinforced concrete 2 ft. 4 in. above the lowest point in the gallery floor to form a balustrade. The general arrangement of the beams and cantilevers is clearly shown, and need not be described in detail. A test was carried out on a portion of this gallery, the portion selected being in one of the corners directly over one cantilever; the load applied being in the form of pig-iron equally distributed to give a pressure of 2 cwts. per sq. ft. The greatest deflection occurred at the outer end, and was only equal to 3.2/64th of an in., while the deflection at the inner end was 0.3/64th of an in. when the entire load was in position, and three hours after its removal the deflection had decreased by one-half. Owing to the impossibility of introducing supports through this gallery and hall to carry the work above, it became necessary to construct the partitions forming the class rooms as beam partitions in order to carry the floors of these class rooms and the gymnasium above them. These partitions have an opening in the centre 7 ft. 6 in. by 6 ft. wide, corresponding with a corridor, and additional reinforcement was necessary around these. They are 12 ft. deep and 12 in. thick, with a span of 50 ft., and the reinforcement consists of ½ in. rib-bars placed vertically at 12-in. centres, with similar bars placed horizontally at 24-in. centres. The upper boom of the girder is formed by a floor slab 5 ft. wide, and the lower flange is heavily reinforced, as shown in the drawing of one of these partitions in *Fig.* 9, which also shows the provision for shear. The necessity for keeping a clear space in the gymnasium involved another problem, which was overcome by constructing the walls of the fives courts as roof principals, and from these

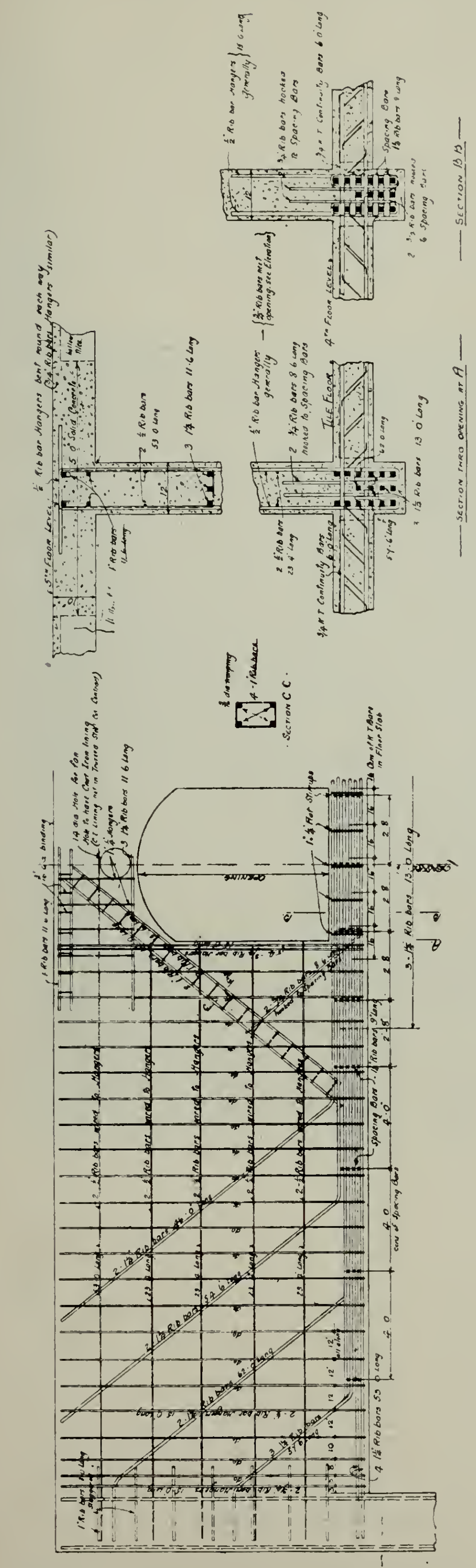


Fig. 9. Details of Beam Partitions.

Y.M.C.A. Building, Manchester.

the floors and the running track around the upper part of the gymnasium were suspended.

A detail of one of these combined roof trusses is shown in the drawing illustrated in *Fig.* 8, which also indicates the outline of the beam in the fives courts. Hangers are provided at every roof truss to carry the outer edge of the track, these being 6 in. by 4 in., reinforced with ½ in. rib-bars in the centre, and connected to the concrete curb, which forms the edge of the track. The inner edges of the track are carried by the constructional walls around same. The principals have a span of about 54 ft., with a depth of 15 ft. 6 in., and a thickness of 14 in., the under surface being curved, as shown in the drawing. The work to the swimming bath is interesting on account of its unique position on the upper floors as previously mentioned. The tank itself is situated between the fourth and fifth floors, this being 60 ft. long by 21 ft. wide, with a maximum depth of 6 ft. 6 in. of water, and a minimum depth of 3 ft. 6 in. The weight of the pool is carried by seven large reinforced concrete beams having a span of 26 ft. in the clear, these being 12 in. wide, and a varying depth according to their relative positions under the bath, as shown in the drawings in *Fig.* 6, the minimum depth being 3 ft. 2 in., and the maximum 6 ft. 2 in. The reinforced concrete forming the sides is 6¼ in. thick at the bottom, with a splay at the top to allow a rebate to be formed for the insertion of the scum trough.

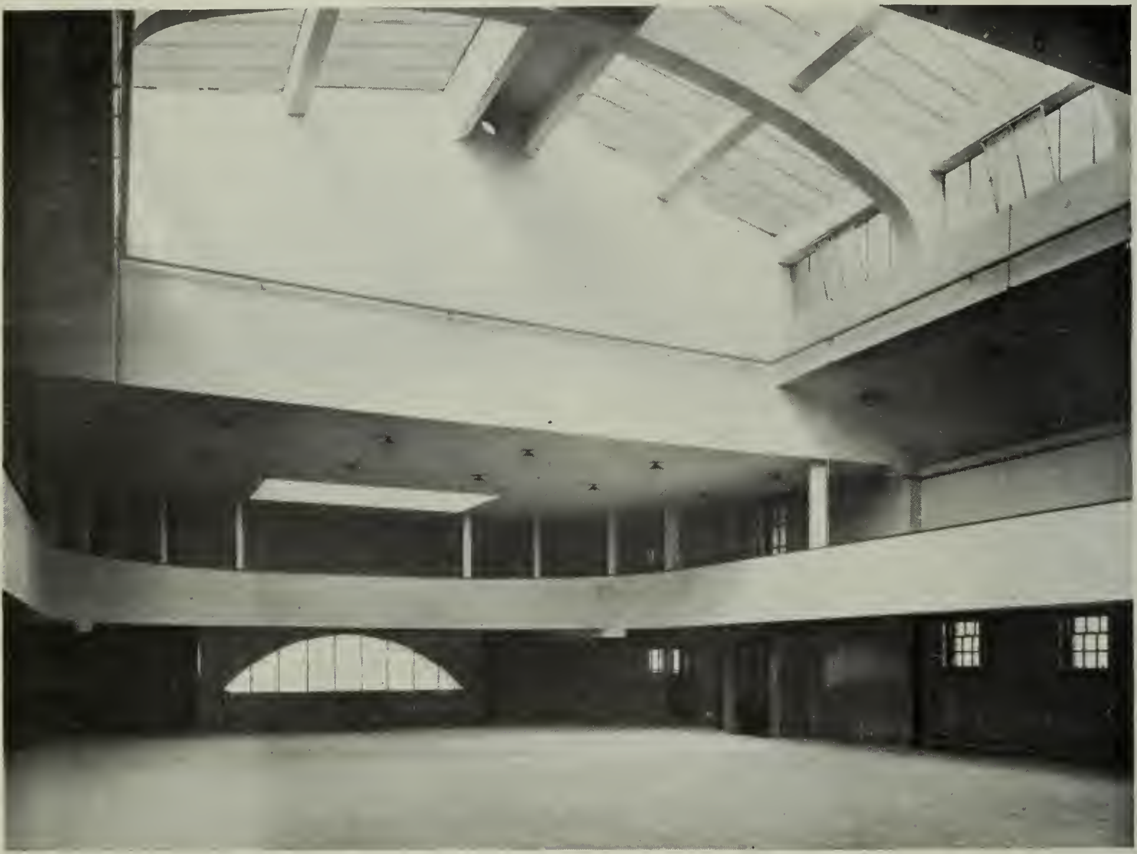


Fig. 10. Gymnasium on fifth floor, with Running Track Gallery.
Y.M.C.A. Building, Manchester.

The walls are also assisted by concrete buttresses at intervals, corresponding with the beams, the thickness of these being about 6 in. To ensure that no water shall percolate through the surrounding work into the lower part of the building, an asphalted tray was formed below the swimming tank between the beams as shown, and this also served the purpose of forming a flush ceiling to the apartment below. The roof trusses over the swimming bath are shown in the drawing illustrated in *Fig.* 7, and it will be seen that the gallery is suspended from the trusses in a similar manner to the running track over the gymnasium. The hangers in this case are 4 in. by 3 in., reinforced by two ½-in. rib-bars in the centre, and connected to the 12 in. by 6 in. curb which forms the outer edge of the gallery. The trusses have a span of 26 ft. 6 in., and are 12 in. thick, the under side being curved to give a minimum depth of 18 in. of concrete. Between the trusses the roof is formed with a 4-in. slab reinforced with ⅜-in. rib-bars at 8-in. centres.

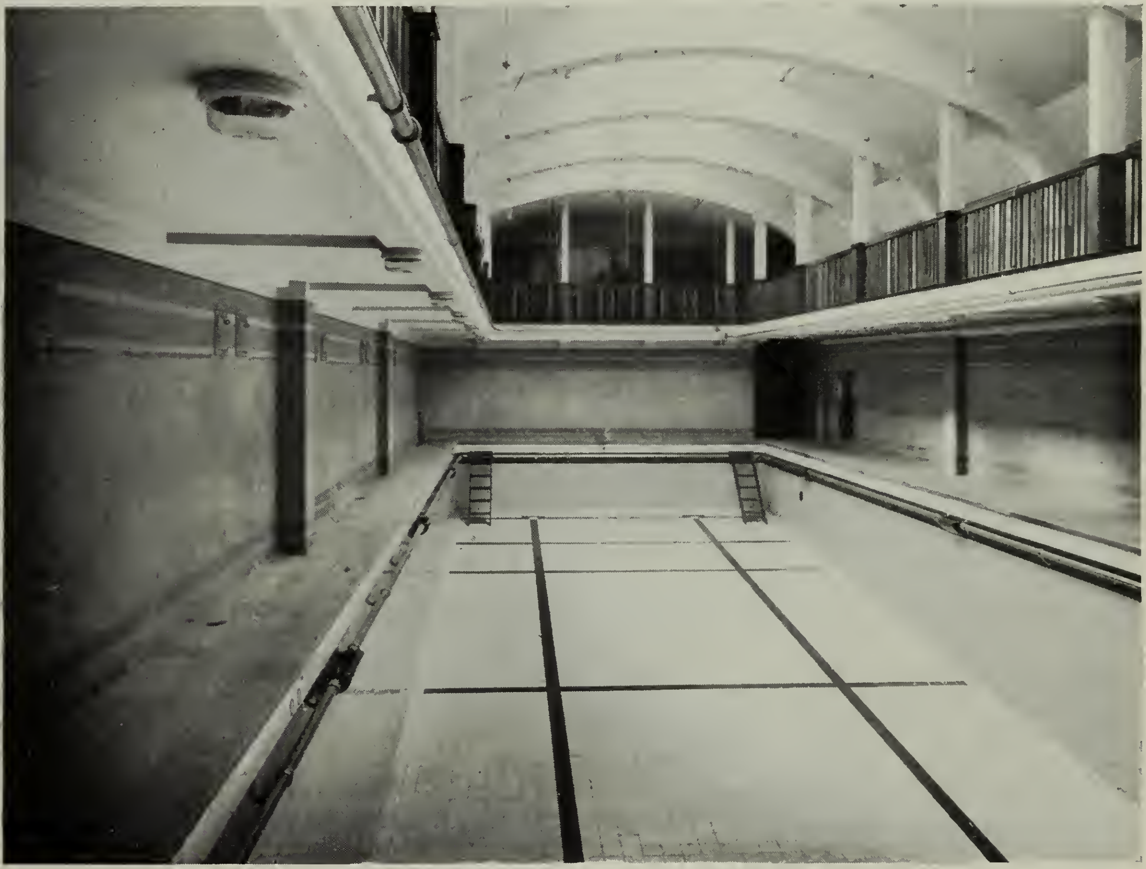
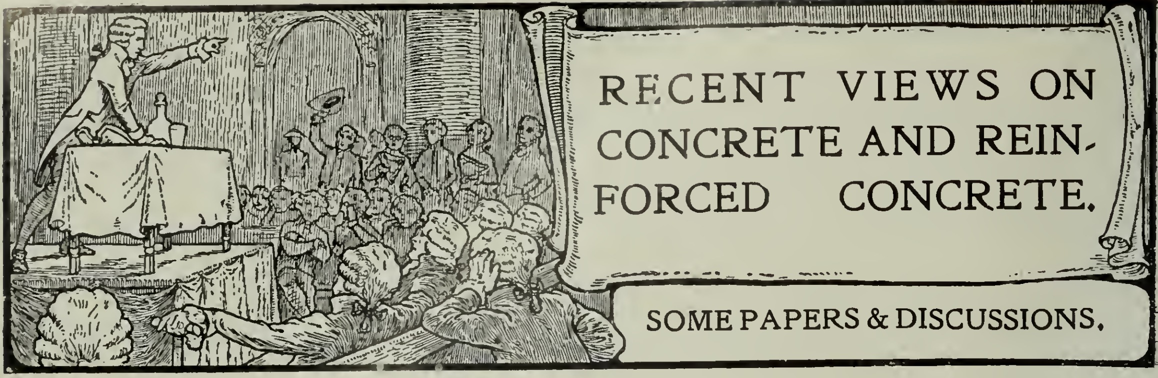


Fig. 11. Swimming Bath on fifth floor.
Y.M.C.A. Building, Manchester.

The work to the bath was tested by filling the latter with water, this being gradually done until it contained about 40,470 gals., weighing about 180 tons. Deflectometers were placed under the two beams at the deepest part of the tank, and after eight days the maximum deflections were ·034 in. and ·042 in. respectively.

Generally speaking, the floor construction, wherever possible, was lightened by the introduction of terra-cotta tubes placed in the underside of the concrete construction with the reinforcement between them. The whole of the concrete was mixed by machinery in the proportions of 4 of stone, 2 of sand, and 1 of Portland cement. The architects for the building are Messrs. Woodhouse, Corbett & Dean, of Manchester, the reinforced concrete construction being designed by the Trussed Concrete Steel Co., Ltd., of Caxton House, Westminster, and executed under the superintendence of their representative.


RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.
SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

SWANSCOMBE REINFORCED CONCRETE PIER.

Paper by C. PERCY TAYLOR, Assoc.M.Inst.C.E.

The following is an abstract of a paper under the above title which was read by Mr. C. Percy Taylor, A.M.Inst.C.E., at the meeting of the Concrete Institute held on April 6th, 1911, *Sir Henry Tanner, I.S.O. (President), in the chair.*

Generally.—The gradual development of the Associated Portland Cement Manufacturers' Swanscombe works since the commencement of their rotary plant in 1899 has resulted in a very large increase in the capacity of the works, and necessitated considerable enlargement of the wharves, more especially for the loading of cement into steamers and sailing ships direct.

The most important point was the provision of a deep-water pier, and after careful consideration an L-shaped concrete pier, with a frontage of 130 ft., and having a depth of 17 ft. at low water and 37 ft. at high water (spring tides), was adopted. A timber dolphin was constructed about 30 ft. from the up-river end for a mooring, and also to form a protection against any shipping which might get adrift.

Owing to the wharf being situated about three-quarters of a mile from the works, the cement has to be transported in covered wagons. It was necessary, therefore, for these wagons and the locomotives to go direct on to the pier in order that the cement might be loaded with a minimum of handling into ships and barges alongside. To provide for all contingencies it was decided to design the pier to carry the maximum number of locomotives or wagons which could possibly be put on it.

In calculating the bending moment of the beams and slabs all live loads were increased by 50 per cent. This was primarily done to allow for vibration and shock.

Foundations.—The foundations consist of thirty-two columns, which, except at the corner, were constructed in pairs on 25-ft. centres, the pitch longitudinally being 28 ft. Each pair of columns is connected just above low-water level by a horizontal brace and at the top by a cross-beam. Between the last three pairs of columns at the outer end of the pier there is in addition a reinforced diagonal strut. Except at this end of the pier, however, it was considered that the L shape of the structure, as a whole, secured sufficient stability, and in actual practice this has proved to be the case.

The top cross-beams are extended at each end to form a cantilever, and into them are built the ends of the nine rows of longitudinal beams. The position of these was arranged to suit the rails, the original intention being to have a full road along each side of the pier with cranes carried on gantries spanning the trucks, so that vessels could be loaded on each side direct from the trucks.

As a matter of fact, it was ultimately decided to restrict the loading of vessels almost entirely to the down side of the approach and the outer face of the pier, it being thought more advantageous to increase the facilities at these points than to make use of both sides with less convenience.

The " full " road at these points was therefore done away with, and a platform constructed with its surface at the level of the truck floor. Loading cranes—which run on rails at the same level—handle the cement from this platform.

Experimental borings in the neighbourhood showed that the bed of the river consisted of a thick layer of mud overlying ballast with chalk below, and that a good footing for piles was not likely to be reached at less than from 60 ft. to 70 ft. from the deck level of the pier. For this reason it was desirable to use a construction which involved a minimum of long piles. The other chief idea underlying the designs adopted was the desirability of carrying the full diameter of the columns right down to the bed of the river without necessitating the deposition of concrete through water. Bearing in mind, therefore, the desirability of depositing as little concrete as possible through water, a system was worked out for constructing the columns in which the concrete carrying the weight of the structure was in the form of blocks moulded on shore and matured before being placed in position.

Arrangements for Constructing the Pier.—It will be convenient to refer briefly here to the general arrangements for constructing the pier. The main idea was the avoiding of false work, the working platform being supported entirely on the permanent structure previously completed. Six heavy pitch-pine baulks about 70 ft. long were carried on timber framings, supported at first on the wharf and later on the top of the completed columns. The overhanging ends of the baulks were stiffened by raking struts, which rested on a cross-timber attached to the base of the columns just above low water, and reached to another cross-timber underneath the ends of the baulks. The main timbers were so placed that the blocks of the columns could be lowered between them. A Scotch crane was erected over the backs of the long baulks. This was found a most convenient arrangement for carrying out practically all the operations necessary for the construction of the pier.

Design of Columns.—The design of the columns provided for blocks, laid one on the other, surrounding a central pile, the blocks being keyed together by a recess and projection and also by rails passing through vertical holes around the central pile. The blocks were further strengthened by ¾-in. round rings. The only concrete which had to be deposited under water was that used for filling around the pile and the rails.

The central pile alone was not sufficient to support the total weight to be carried by each column—about 150 tons as a maximum—but, on the other hand, the carrying of more than one pile through the column would have necessitated either a very large diameter or else a block with very little solid material in it. It was therefore proposed to rest the base of the column on some additional piles driven round the centre one and cut off at about ground level. In order to secure ample rigidity for the connection between the piles and the column the bottom blocks were made in the form of a hollow shell. These were firstly made in reinforced concrete throughout, in the belief that the bed of the river would be sufficiently soft for them to be forced through the upper layers to form a key. Experience with the first few columns, however, indicated that this was not the case, and afterwards the sides of the shells were made of steel plate fixed to the reinforced concrete top. To further increase the rigidity of the column base a hollow was grabbed out in the bed of the river at the side of each column so that the top of the shell-block actually came about level with the bed of the river, the hollow being afterwards filled with concrete in bags.

The driving of the additional piles and the cutting off of them at the level of the ground was a simple enough operation in the first few columns above low water, but it would doubtless have proved costly both in execution and timber when working in deep water. It was therefore decided to try a system of dollying them down to a dead level, and this was found by experience to work very well indeed.

Although the points of these piles reached an average depth of 60 ft. below the working platform, their average length is only 15 ft.

After the centre pile and the three smaller piles had been driven, the building up of the column proceeded as follows : The bottom shell-block being placed on the temporary decking, two long bolts were attached to it, with "T" heads passing through slots in two special bars built in on each side of the hole for the centre pile. The shell-block was then lifted by means of these two bolts and dropped over the pile. The bolts had flanged projections riveted on to them near the top, and these were attached to the centre pile in such a position that the top of the shell-block was just above low water. The column was then built up block by block, until the total length was about 10 ft. A cross-bar was then placed over the top of the central pile, and two sets of tackle slung from this on to the tops of the long bolts. The fall ends of the two wire ropes in these tackles were attached to the crane hook. When the water was high, and the whole of the column was submerged, the crane was able to lift the column sufficiently to release the long bolts from the pile, and the bottom part of the column was then lowered about 10 ft. and the flanged projections again fastened to the central pile. Building up then proceeded block by block till the column was about 20 ft. high. Three of the rail holes went through the shell-block and three were blind. Rails were inserted in the latter three and grouted up, the bottom portion of the column was then ready for lowering on to the piles. The top cross-bar and tackle were again fixed up and the column lowered until the edge of the shell-block began to pierce the mud. The lowering operation was carried out in two parts to reduce the risk of swaying of the pile, owing to the tide action on the column, and the pile was also stiffened when necessary by temporary bracing from the cantilevers.

The length of this portion of the column was such that when it was in place the top was above water at low tide, thus enabling the rest of the column to be built up in the dry. Before the upper part of the column was built on, however, the three additional rails were inserted in the holes previously empty. These projected through to the ground, and grout was poured down the holes surrounding them. In order to ensure that the shell-block was properly filled, three special vent holes were provided in it just outside the circumference of the column. Pipes were attached to these three vents and brought up above low water, and the grouting was not stopped until the grout overflowed each of these pipes. The vent pipes were afterwards unscrewed close to the shell-block, and when the short lengths of pipe left in place were examined it was found that the grouting up had been entirely satisfactory except in two cases. These blocks were then filled up.

Just above low-water level a taper block was introduced to reduce the diameter of the column from 5 ft. 6 in. to 4 ft. 6 in., and above this the first 4 ft. 6 in. block had a dovetailed recess in the side to receive the end of the horizontal brace, each end being arranged so that one of the vertical rails in the column passed through it to give it a good key. The top of the column was formed into a square with a projection on the outer side to help in forming the cantilever.

Next the longitudinal beams were placed. These were all of identical design. They were moulded on shore and lifted into place by the crane, being temporarily supported on rolled steel joists going right across the pier on each side of the column tops, these being slung from needle beams.

After the placing of the nine longitudinal beams the moulding of the main cross-beam and stiffener was taken in hand. The shuttering for the main cross-beams was of the simplest possible kind. The base was laid direct on short cross-bearers supported on the main rolled steel joists. The side shuttering in place for the end cross-beam was formed in bays, each of five pieces, which were hinged together. The middle piece was rather shorter than the distance between two longitudinal beams. The side pieces were each about 18 in.—to form the end of the longitudinal beams—and the intermediate pieces were about 2 in. long and hinged to each of the others so as to form an adjustable fillet. The stiffener was formed in a similar manner, but the bottom shuttering for this had to be slung from the longitudinal beams.

The shuttering for the decking was carried on timbers bolted to the longitudinal beams through small holes especially left for the purpose.

Longitudinal Beams. — The longitudinal beams themselves, without the T portion formed by the slab, have to carry the weight of all the shuttering and the concrete forming the deck. The beams as moulded and placed in position by the crane were 12 in. wide, 36 in. deep, and had a span, resting on the rolled steel joists, of 22 ft., and they were, of course, considered as freely supported at the ends. Under these conditions they have an effective height of 34 in., the neutral axis is at a depth of 14 in. from the tops and the radius arm is 29·5 in.

The load which they have to carry under these conditions is made up as follows for the three centre girders :

	Tons.
Floor	11
Three Beams	16·8
Shuttering	1·2
Total	29

This is equivalent to a bending moment of 68 ft.-tons on the span of 22 ft., or, say, 23 ft.-tons per beam, which, with 3·83 sq. in. of tensional steel per beam, introduces a tension stress in the steel of 5,480 lb. per sq. in., and a compression stress in the top of the concrete of about 250 lb. per sq. in. This condition of loading —except that due to the shuttering—is permanent, and causes, moreover, no stress in the floor slab whatever. The floor slab is only stressed by the permanent way locos and wagons. On completion of the decking, therefore, a somewhat unusual condition exists—a beam, subjected to bending, and with its top surface, therefore, in compression, being practically monolithic with a slab which is unstressed.

The author then proceeded to give a detailed calculation, with illustrations, for obtaining the bending moment for the completed beams.

Considering the design of the pier as a whole, objection may be raised that the idea of making the various portions on shore and connecting them together *in situ* is not consistent with the monolithic idea underlying reinforced concrete design. The author did not, however, consider that any such criticism is valid, in view of the fact that no structure of such a size can be said to be built in anything but small parts in actual practice.

With even less rigid precautions than were adopted in this case, the author felt that the manufacture of separate members is amply justified where the work may be more simply and cheaply carried out by that method, and that where shuttering is specially expensive and difficult the method might well be adopted a good deal more often than it is at present.

MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

THE ADAPTABILITY OF REINFORCED CONCRETE TO MINING ENGINEERING.

Paper by R. N. MIRZA, B.Eng.

The following is an abstract of a paper entitled "The Adaptability of Reinforced Concrete to Mining Engineering" read by Mr. R. N. Mirza at the meeting of the Midland Counties Institution of Engineers recently held at Nottingham.

Introduction.—Whilst advocating the use of reinforced concrete in mining engineering, with a view to increased safety both above and below ground, the writer was unable to give actual examples of work carried out in this country, but was of opinion that this material is eminently suitable in lessening some of the dangers met with in everyday mining work.

For the benefit of those members who were not familiar with the functions performed by the concrete and the steel respectively, a short *précis* of the theory of reinforced concrete might not be out of place. Concrete in compression is considerably stronger than in tension, and the best authorities, such as the Royal Institute of British Architects, recommend as a safe stress 600 lb. per sq. in., whilst they consider the tensile stress to be almost *nil*. There seems, however, to be considerable difference of opinion amongst engineers, both in Great Britain and abroad, as to whether or not, in calculating designs, the resistance of concrete in tension should altogether be neglected. Prof. Hart, in America, and Mr. Considère, in France, advocate that an allowance should be made for this resistance, whilst the majority of other experts neglect such an allowance, and the writer thought that it was better to do so at the present time. The problem was, therefore, to strengthen the structure in some manner in the portion subject to tensile stresses, leaving the concrete to resist the compressive stresses by its own strength, so long as the latter are within the limits of the safe value allowed—that is, 600 lb. per sq. in.—as, if not, a certain amount of reinforcement would also be required for compression. Steel being very strong in tension, it is eminently suitable to take up all tensile stresses, so that a combination of steel and concrete makes the structure strong in tension and compression.

It was fortunate that, so far as elongation or contraction due to changes of temperature was concerned, both materials might be taken as acting together. Prof. W. D. Pence, of Purdue University, U.S.A., had made considerable research in the attempt to discover the co-efficient of expansion of Portland cement concrete, and had found it to be, on an average, 0·0000055, the co-efficient of expansion of steel being taken as 0·0000067. Taking the highest values, the difference of deformation of the concrete and steel for a change of temperature of 70° Fahr. (21° Cent.) would be only 0·12 in. for a length of 100 ft. Mr. Coignet gave for every 1·8° Fahr. (1° Cent.) rise in temperature the co-efficient of expansion for steel as about 0·0000148, and for concrete, 0·0000135. From these figures, it was evident that nothing much was to be feared so far as temperature stresses were concerned, except in walls of considerable length.

The simplest form of efficient reinforcement for resisting tensile stresses appeared to be ordinary round steel rods. The shearing stresses of a structure had, however, to be taken into consideration, and the general method of resisting these was by the use of what are known as "stirrups," which are bars or strips fixed to the main reinforcing bar at intervals, and bent to certain angles. These stirrups (or shear members) are generally bent at an angle of 45° to the main tension rod ; they thus pass through the planes of rupture at right angles, and therefore are of maximum efficiency in preventing such planes of concrete from tearing asunder. It had also been found desirable that the stirrups should be rigidly attached to the main tension rod. Loose stirrups had also the disadvantage of being liable to be displaced by the workmen during the process of ramming the concrete, an operation most essential in order to obtain good workmanship.

Reinforced Concrete for use in Electrical Work.—After a short *résumé* of the principal systems of reinforcement, the writer went on to the question of the suitability of reinforced concrete for use in connection with electrical purposes, electricity being at present so extensively used to increase the output of mines and to reduce the cost of production.

To mining engineers who might have found some difficulty in protecting bunches of cables underground, the following suggestion might be interesting. Wind first a sisal rope, $\frac{1}{4}$ in. in diameter, spirally around the cable with a pitch of about $\frac{1}{2}$ in., then apply by means of a pad and brush a mixture of 1 part of cement and 2 parts of sand. This not only affords a protection against mechanical injury, such as accidental damage by tools, rough handling by inexperienced workmen, etc., but serves to locate a short circuit in the cable by the bursting of the cement—in fact, it is even superior to asbestos.

A few general applications of the use of reinforced concrete in mining were then given :

Pit Props.—These being fireproof, were very reliable, and although slightly heavier, were very much stronger than timber.

Lining of Underground Roadways.—In this connection the writer drew attention to the adaptability of reinforced concrete slabs, say, 3 in. thick reinforced to stand heavy breaking loads, and prepared and matured above ground. These can be utilised for supporting the roof of the roadway with beams at, say, 6-ft. centres.

Reinforced concrete lining for main roads was adopted about four years ago at the Béthune Mines, in the Pas-de-Calais coalfield, for the protection of a certain section of the road originally supported by steel girders resting upon masonry walls about 18 in. thick. It was interesting to note that the present lining of reinforced concrete was only about 8 in. thick, and that no skilled labour was used in its construction.

There were four distinct advantages in lining roads with reinforced concrete—namely : (1) Resistance to explosions and shocks ; (2) undue accumulation of dust prevented, owing to smoothness of surface : such a road could be swept or watered ; (3) less resistance is offered to the air-current ; and (4) no depreciation in strength and efficiency concurrently with age.

At the Providence Pit, Charleroi (Belgium), the deepest colliery in the world, a scheme had been devised whereby reinforced concrete would be used to support the whole length of a level subject to great pressures. The Philadelphia and Reading Coal and Iron Company, Pennsylvania, use reinforced concrete extensively in their roads, where, owing to double tracks, long spans and arches supported on columns are necessary. When first employed, these columns were made 24 in. square, but the later ones had been reduced in size to 18 in. Old rails, conveniently bent, wire ropes, etc., were used as reinforcement, and are easily and readily obtained on the spot.

Sleepers.—For sleepers in mines where the wear and tear was very considerable, reinforced concrete was an ideal substitute for timber, and although slightly in excess in first cost over the latter, such sleepers were far more economical in the end, as they were practically indestructible.

Engine Foundations.—For foundations of all descriptions reinforced concrete was incomparable, being much better than mass concrete, besides saving a considerable amount of excavation.

Bins.—Many coal- and ore-bins had been constructed of this material, the saving in first cost and annual upkeep for scraping and painting over steel being very marked.

Airways.—An excellent use of reinforced concrete pipes (which could be made in lengths up to 18 ft.) was suggested—that is, for the lining of airways, thus giving a good smooth passage, as there was always a little difficulty in keeping small airways thoroughly clean and free from falling *débris* when constructed in the ordinary way.

Bulkheads.—The writer believed that it was fairly common practice nowadays to build bulkheads in the galleries for resisting large quantities of water, and reinforced concrete was very efficient for their construction, being very strong and capable of resisting great bursting pressure.

Sanitary Uses.—In addition to the few uses of reinforced concrete above mentioned, and the many others too numerous to be described, the writer drew attention to the value of this material for raising the standard of mining hygiene. He feared that this matter did not meet with the attention which it merited from those responsible for the care and safety of the colliery. Excellent sanitary stabling arrangements could be made by the use of reinforced concrete slab work, made as before mentioned, the reinforcement necessary being light steel meshwork. The great advantage of using this material was that it could be thoroughly cleansed by swilling with a hose, and, in addition, organic acids had no deleterious effect.

It was impossible to prophesy at the present period the ultimate uses to which reinforced concrete would be put ; but there was no doubt that the material had now passed the experimental stage, and offered a vast field of investigation and enterprise to those interested in mining engineering, whether from the standpoint of economy or from that of improved hygiene and efficiency of the employees.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

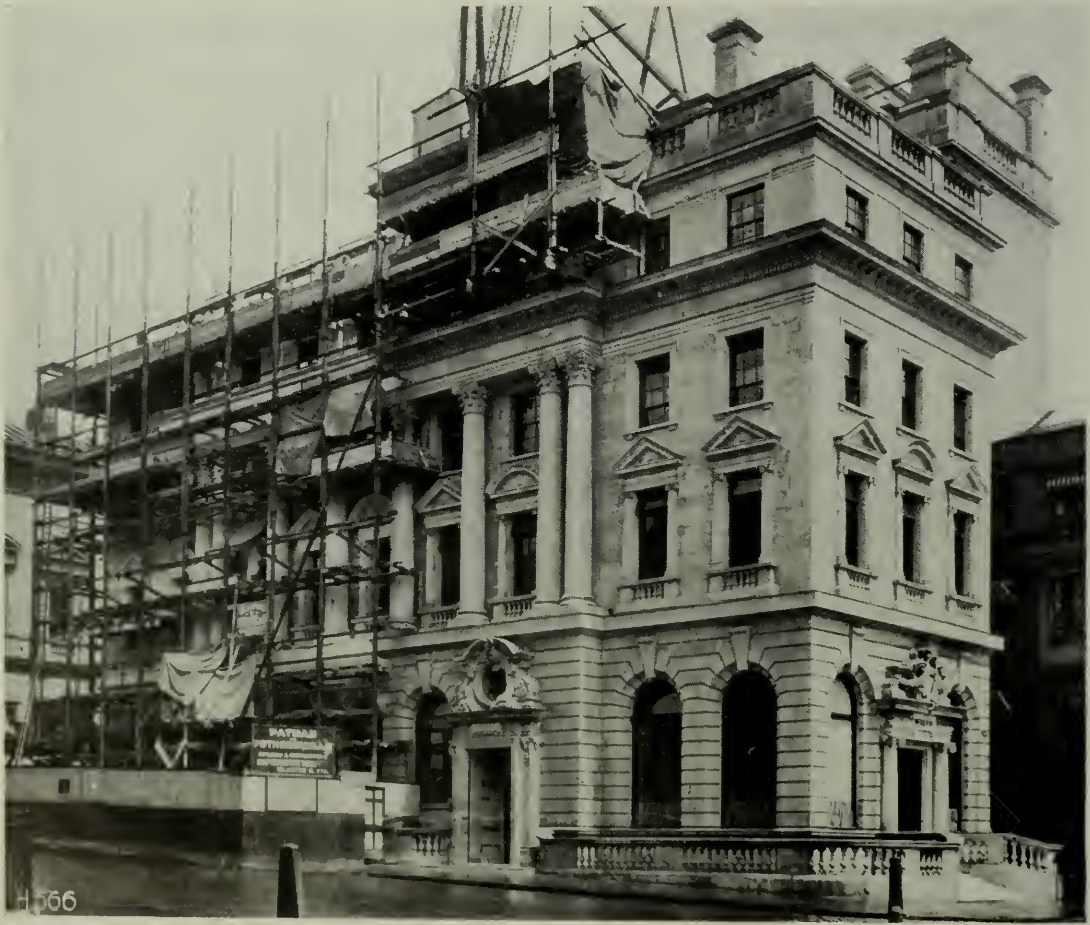
Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

NORTH BRITISH AND MERCANTILE BUILDING, WATERLOO PLACE, S.W.

ONE of the finest buildings that have recently been erected in the West End of London is that forming the new premises for the North British and Mercantile Insurance Co. in Waterloo Place. This palatial block of buildings is a steel-framed structure with reinforced concrete floors and roof. The whole of the columns and girders are encased with concrete in accordance with the London Building Act. The entire building is 100 ft. by 60 ft., and consists of five floors and a flat roof.

The building had to be constructed in two parts, owing to the requirements of the former tenants, and as a new addition will be built in about five years' time the work was constructed in such a manner that when a portion of the western wall of the building is pulled down, the floors can be continued into the new addition.

One of the special features of the construction is the size of the floor slabs, the largest of these being 24 ft. by 20 ft., and the average about 17 ft. square. All slabs are independent of each other, and bear on all four sides. In several instances, owing to the exigencies of the case, the centering of these very large spans was struck within

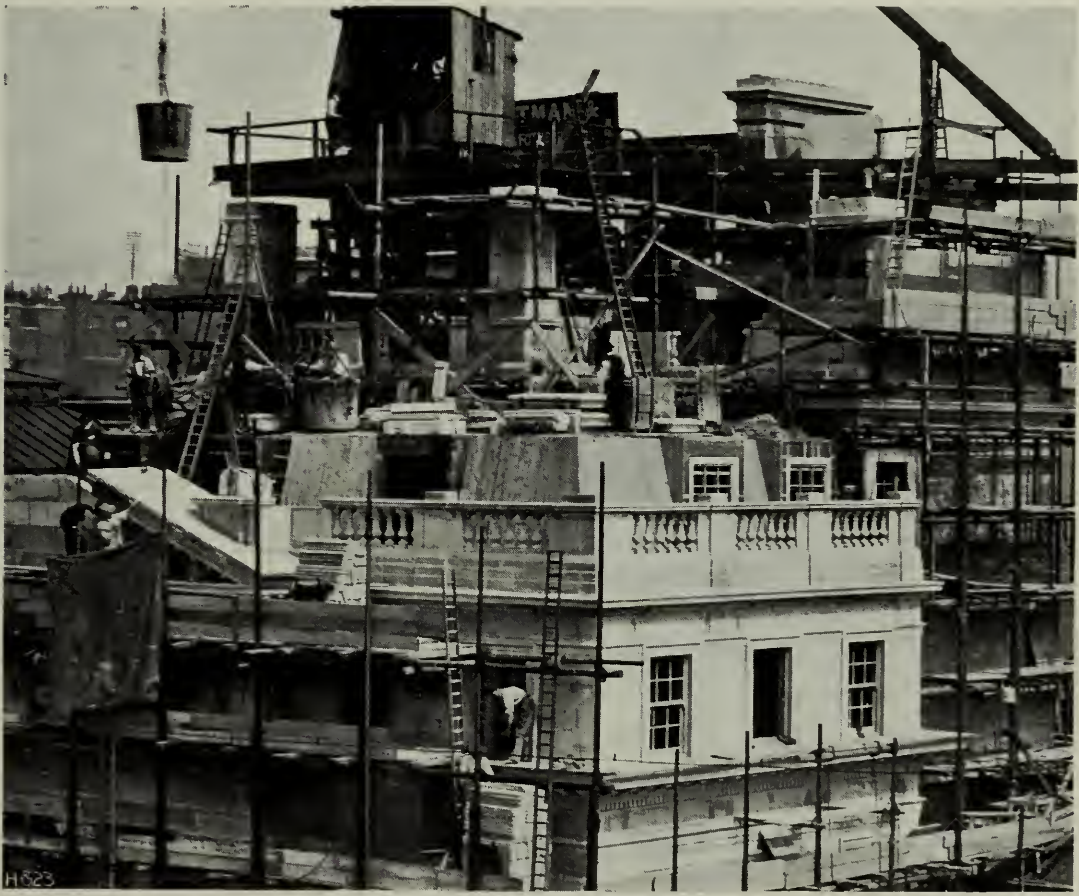


View in Course of Construction.
NORTH BRITISH AND MERCANTILE BUILDING, WATERLOO PLACE, S.W.

10 days without any deflection being observed. No test has been made of the slabs, but they were loaded up on more than one occasion with builders' material to the extent of over 3 cwt. per sq. ft. ; they were designed for a load of 1 cwt. per sq. ft. The floors are generally 7 in. thick throughout.

The whole of the roof is constructed of reinforced concrete. The sloping fall of the Mansard roof is made of breeze concrete, so as to enable all slates, etc., to be secured to the same without the use of battens. Stairs are of concrete, faced with marble.

The aggregate throughout was formed of 3 parts crushed brick ¾ in. down, the whole of the dust having been eliminated, 2 parts of washed Thames sand, and 1 part of Portland cement. The latter was the J. B. White brand, supplied by the Associated Portland Cement Manufacturers (1900), Ltd. All bricks were well wetted before being mixed with the sand and cement, so as to prevent the rapid absorption of moisture from the concrete.



View of Roof during Construction
North British and Mercantile Building, Waterloo Place, S W.

The whole of the work was carried out by Stuarts Granolithic Co., Ltd., of 4 Fenchurch Street, on the " Wells " system, designed by Mr. E. P. Wells, of 94 Larkhall Rise, Clapham, S.W.

The architects were Messrs. Thompson & Walford, and the builders were Messrs. Patman & Fotheringham, Ltd.

REINFORCED CONCRETE CHIMNEYS IN DENMARK.

Chimneys of reinforced concrete of a type entirely different from any others have for the last two years been constructed in the Scandinavian countries by the " Danish Concrete Beam Co., Ltd.," of Copenhagen.

The type of chimney built and patented by this firm is called the " Shamrock Chimney " on account of the peculiar shape of the lower part of the chimney, the

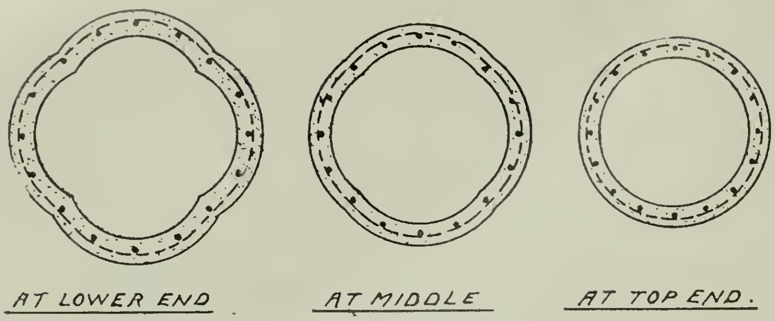


Fig. 1. SECTIONS OF "SHAMROCK" CHIMNEY.

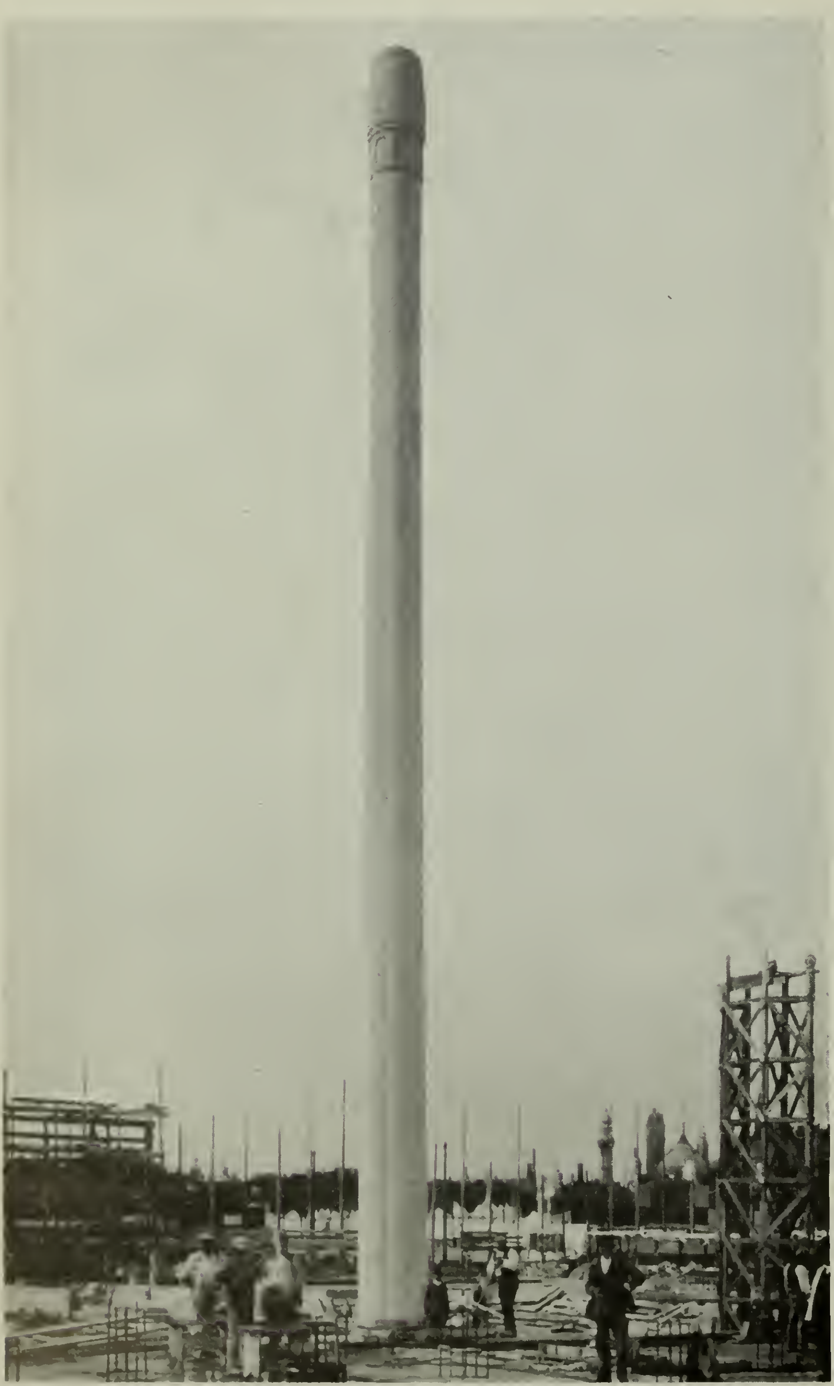


Fig. 2. "Shamrock" Chimney for the General Post Office, Copenhagen.
REINFORCED CONCRETE CHIMNEYS IN DENMARK.

section of which reminds one of a four-leaved Shamrock. The reason for making the chimney of this shape is, that the forms for the upper and lower parts of a chimney are made to the same radius, thereby minimising the labour required for altering the forms, as they are moved upwards and used over and over again during the construction.

The sections of a "Shamrock" chimney are shown in *Fig.* 1. The section at the lower end consists of four arches of a circle, each arch a little over 90°, corresponding to the taper wanted in the chimney. As the chimney is brought upwards, the length of each arch is shortened a certain amount, and at the top the arches are just 90°, forming a true circle. The result is a tapered chimney of very pleasing effect, contrary to the rather unsightly parallel shaft, usually made of reinforced concrete.

Of the illustrations shown, *Fig.* 2 is a chimney recently erected at the new General Post Office in Copenhagen, and *Fig.* 3 represents a "Shamrock" chimney over 150 ft. high during construction. Altogether the Danish firm has erected over twenty reinforced concrete chimneys during the last couple of years in Denmark, Sweden, and the West Indian Islands, and the chimneys have in every case given perfect satisfaction.

The "Shamrock" chimney is being introduced into the United Kingdom by Messrs. J. & W. Stewart, of London, Belfast, and Dublin.

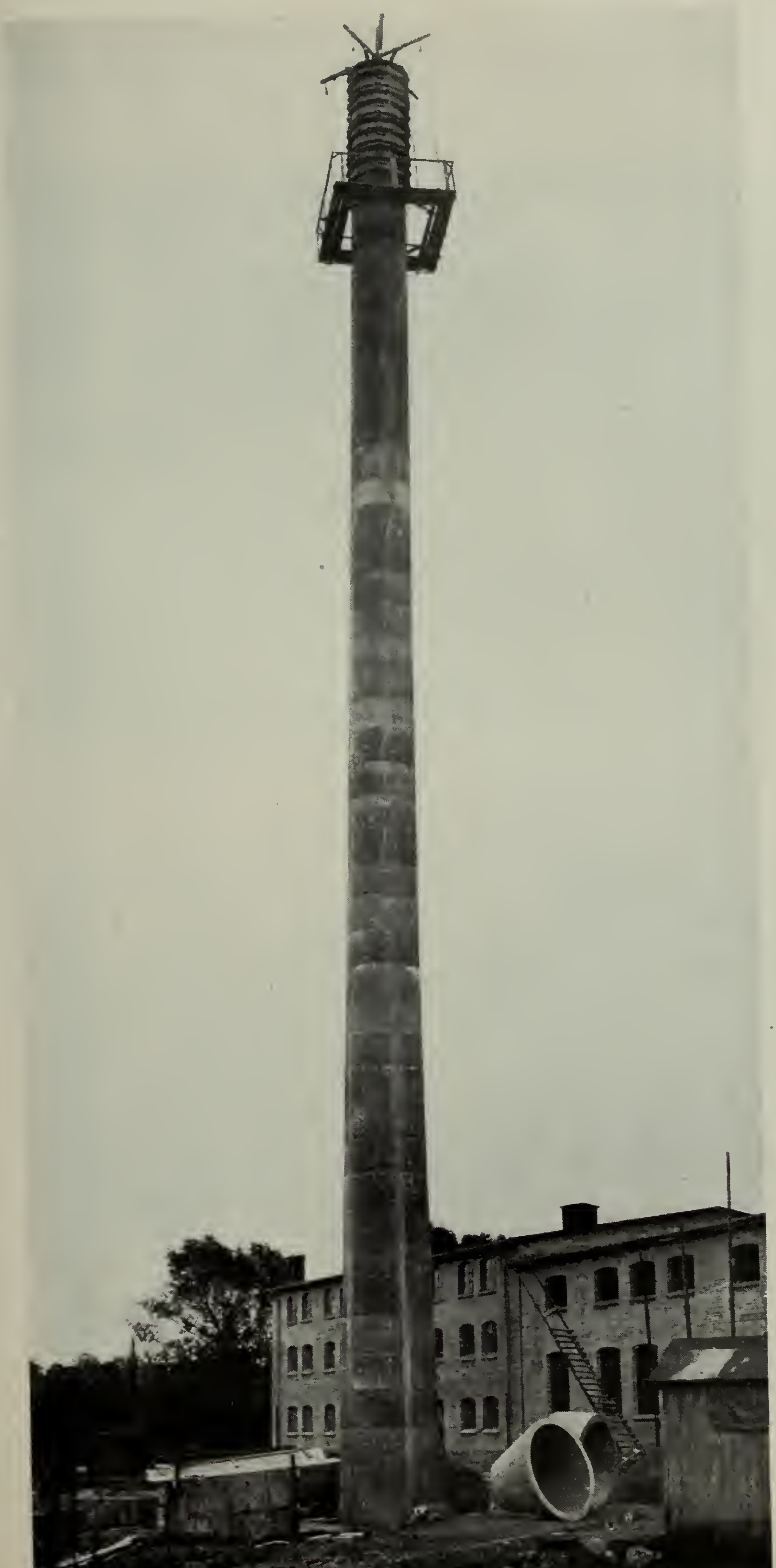


Fig. 3. "Shamrock" Chimney, over 150 ft. High, during Construction.

REINFORCED CONCRETE BRIDGE AT BOSMERE, SUFFOLK.

The East Suffolk County Council have recently reconstructed several of their road bridges, among which is that at Bosmere, near Needham, which we illustrate on page 388.

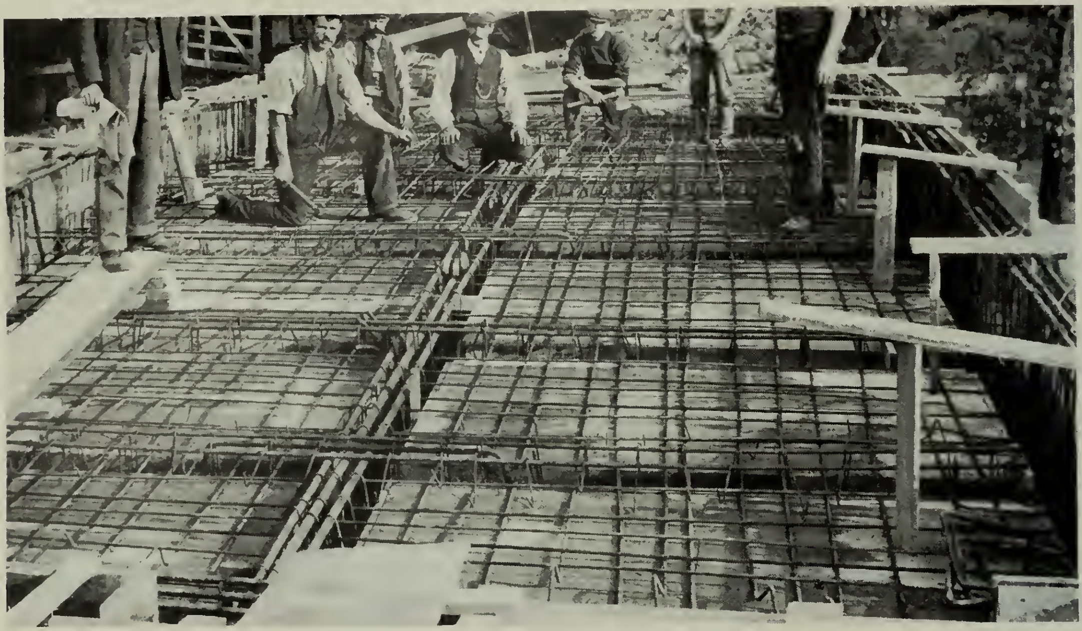
This bridge, originally a timber structure, was in a very bad state of repair, and reinforced concrete having been selected for the reconstruction, the contract was let to Messrs. D. G. Somerville & Co., Victoria Street, Westminster, S.W., who have carried out many similar structures. The existing brick abutments were found to be in fair condition, and it was therefore decided to utilise these, and by cantilevering to reduce the weight as much as possible.

As will be seen from the illustration of the completed structure, intermediate supports were formed by two sets of reinforced concrete piles, each set consisting of three. These piles were manufactured in Messrs. Somerville's yard in London, and delivered right on to the site, ready for driving.

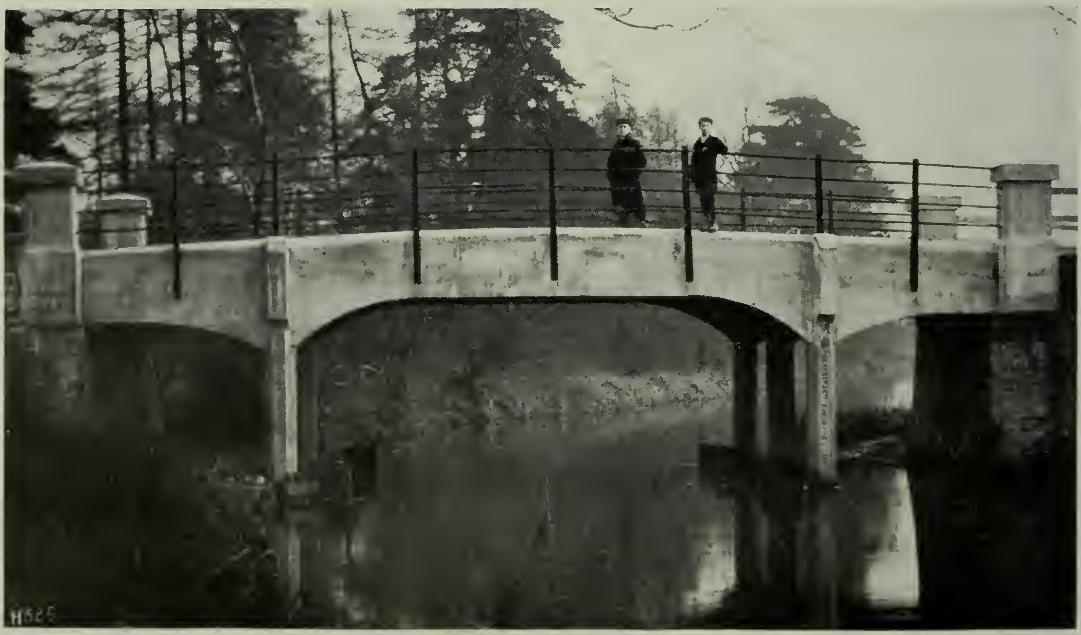
The bridge consists of three spans, the outsides being 9 ft. and the centre 22 ft., the total length being

40 ft., with a width of roadway of 18 ft. The piles were driven with a 30-cwt. monkey until the required set was obtained, the heads then being cut down to form a connection for the main beams. We illustrate the plan and section on page 389, showing the reinforcing, which was on the Considère system.

Some six weeks after the completion, the bridge was tested by the County Engineer, Mr. H. Miller, with a 15-ton traction engine, no appreciable deflection being observable. The whole of the work was carried out under the supervision of the County Engineer, the actual bridge being built in the short space of six weeks.



Floor of Bridge during Construction.



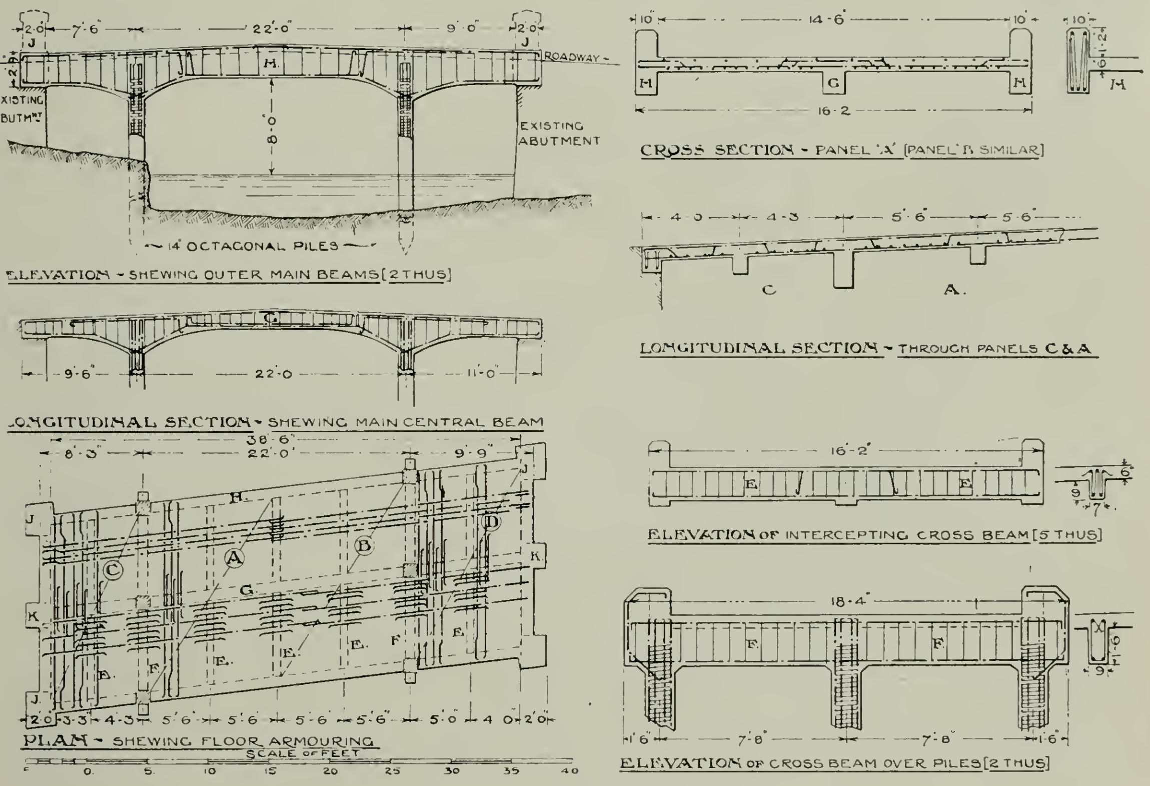
View of Finished Structure.
Bosmere Bridge, Suffolk.

STRENGTHENING STEEL TRESTLES ON THE WABASH RAILWAY, U.S.A.

An interesting piece of work has recently been completed on the Wabash Railway, U.S.A., where a steel trestle has been converted into a reinforced concrete structure by encasing the original columns and struts with concrete in which is embedded the necessary additional amount of steel reinforcement. This was done with a view to preventing rust on the interior of the columns, and also to strengthening them.

The columns and struts are four section Phœnix columns, and the former are converted into octagonal concrete columns 18 in. diameter over the faces, reinforced by a spiral wrapping of wire. The base is a rectangular concrete block, reinforced by a cage of steel rods. The concrete struts are 7½ in. by 7½ in., each reinforced by eight ½-in. rods, around which is wrapped heavy-woven chicken wire; the struts are united to the columns by means of gussets.

The reinforced concrete bases were cast first. The spiral reinforcing was threaded on the columns and held in place by steel spacers and anchored to the columns. Then the boxing for the forms was placed, and when a sufficient number was ready, concrete was run into them from a train on the trestle.

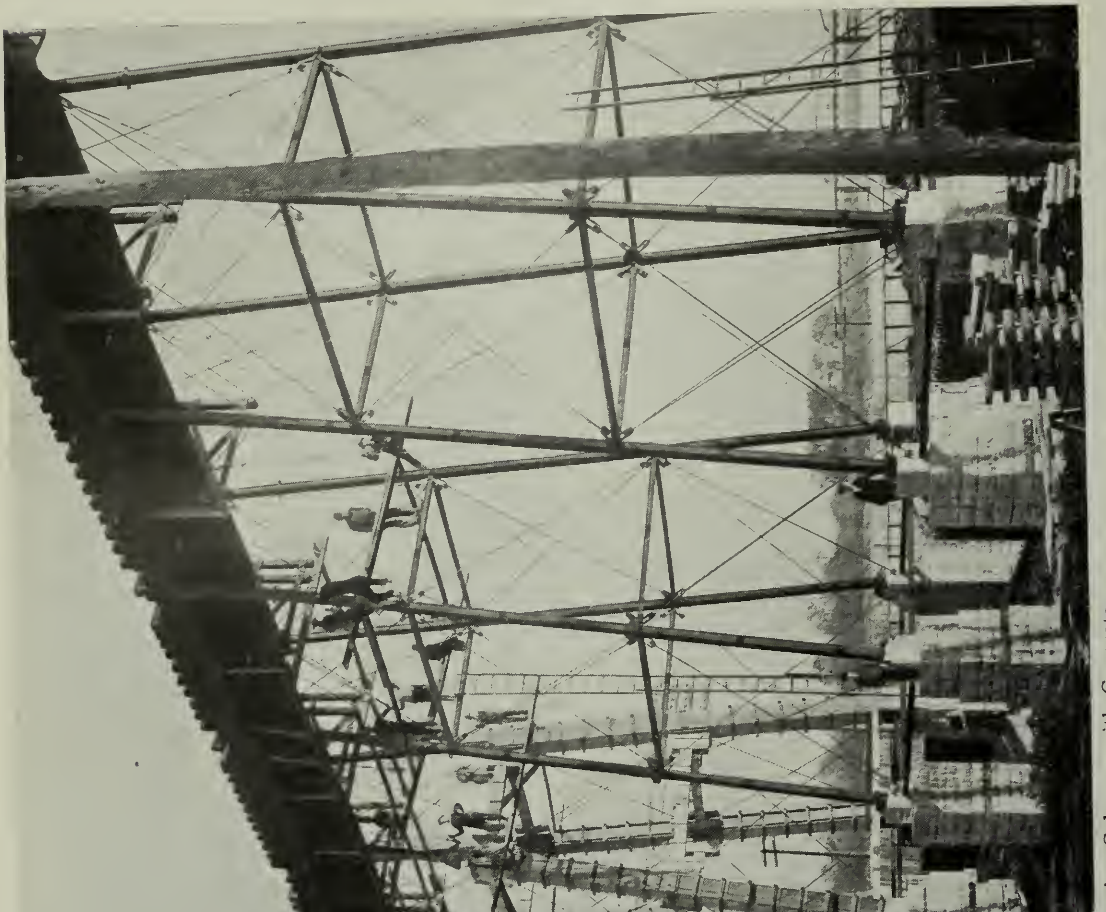

ELEVATION - SHEWING OUTER MAIN BEAMS [2 THUS]
ROADWAY
EXISTING ABUTMT
EXISTING ABUTMENT
14" OCTAGONAL PILES
LONGITUDINAL SECTION - SHEWING MAIN CENTRAL BEAM
PLAN - SHEWING FLOOR ARMOURING
SCALE OF FEET
0 5 10 15 20 25 30 35 40
CROSS SECTION - PANEL 'A' [PANEL 'B' SIMILAR]
LONGITUDINAL SECTION - THROUGH PANELS C & A
ELEVATION OF INTERCEPTING CROSS BEAM [5 THUS]
ELEVATION OF CROSS BEAM OVER PILES [2 THUS]
A
B
C
D
E
F
G
H
J
K

Plan, Elevation, and Sections.
Bosmere Bridge, Suffolk.

Some years ago the columns were filled with concrete, and according to tests previously made of these columns so filled the strength had been increased in this way about 10 per cent. However, as it was necessary to further increase the strength of the columns, the reinforcing work described above was decided on. Before this was done a test was made on one Phœnix column that was in stock. This column was 27 ft. long. A piece 5 ft. in length was cut from this and was tested as a steel column of this length. The rest of the column, which was 22 ft. long, was strengthened with concrete and reinforced exactly as in the trestle described. Both the 5-ft. plain steel column and the 22-ft. reinforced column were tested by Professor Talbot, of the University of Illinois. From these tests it was found that the column strengthened with concrete and spiral reinforcement was about twice as strong as it was previous to the application of the reinforcement.

It is believed that the columns so reinforced will be strong enough to carry the heaviest engines in existence.

The concrete was composed of 1 part Portland cement and 3 parts coarse sand.



Encasing Columns with Concrete

Strengthening Steel Trestles on the Wabash Railway, U.S.A.

This was made quite wet so as to ensure a dense mixture and a complete surrounding of the steel reinforcement.

The plans were prepared and the work done under the supervision of Mr. A. O.

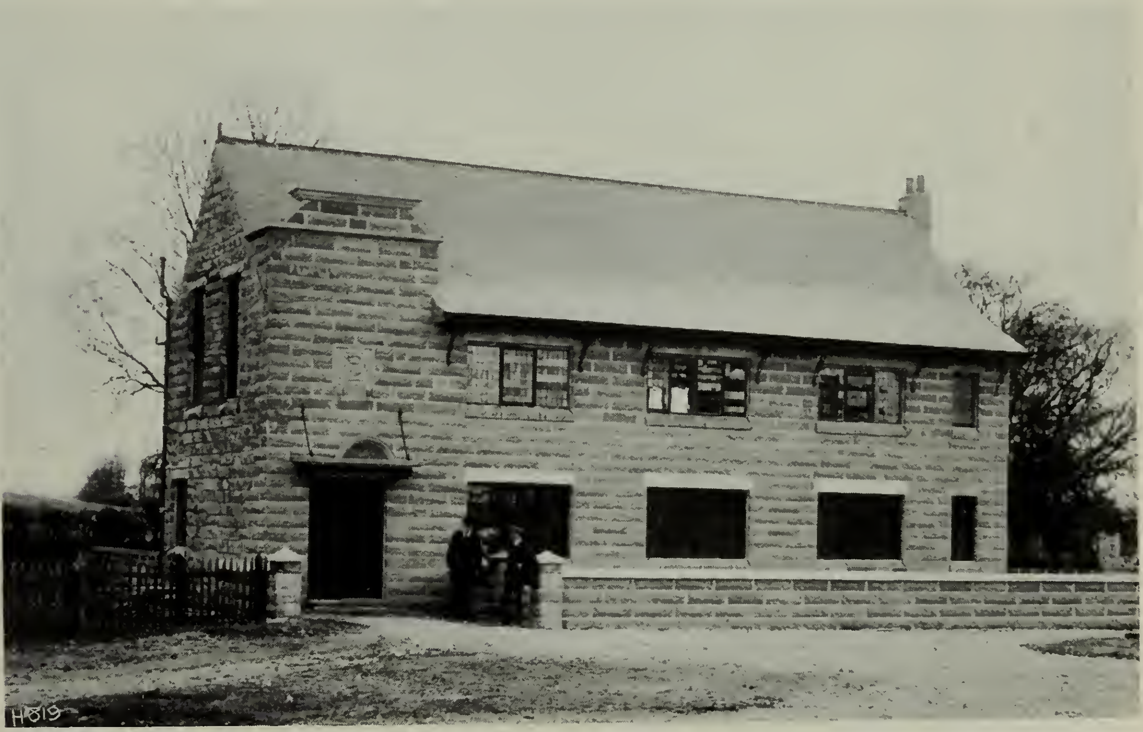
Cunningham, Chief Engineer of the Wabash Railway, to whom we are indebted for our particulars and illustration.

CONCRETE BLOCKS IN IRELAND.

At Talbot's Inch, Kilkenny, there is a most interesting industrial settlement which is being directed and run by the Dowager Countess of Desart, and Captain the Hon. Otway Cuffe. The industries represented are the Kilkenny woodworkers, the Kilkenny woollen mills, and tobacco plantation. In addition to providing splendid cottages for the workers, the village hall illustrated below has been erected for their use.

The building is 58 ft. long by 26 ft. wide. It contains on the ground floor entrance hall, recreation room (two full-size billiard tables, etc.), kitchen, etc. On the first floor there is a concert hall with stage, proscenium and seating for an audience of 230.

The architect of the building is Mr. F. W. Kiddie, of Knock-na-Cree, who states that it was opened eight weeks and two days from date of laying the foundation, and that only one mason was employed with the assistance of four or five labourers after the first day and a half, when two masons were at work, which speaks well for the ease and rapidity with which concrete blocks may be laid.



Village Hall at Talbot's Inch, Kilkenny, made of Concrete Blocks.

The "Winget" blocks were supplied by the Concrete Block Co., of Talbot's Inch, who have installed a complete plant furnished by the (U.K.) Winget Concrete Machine Co., Ltd., Newcastle-on-Tyne, consisting of an "Express" Concrete mixer and 32-in. standard "Winget" concrete block-making machine and outfit.

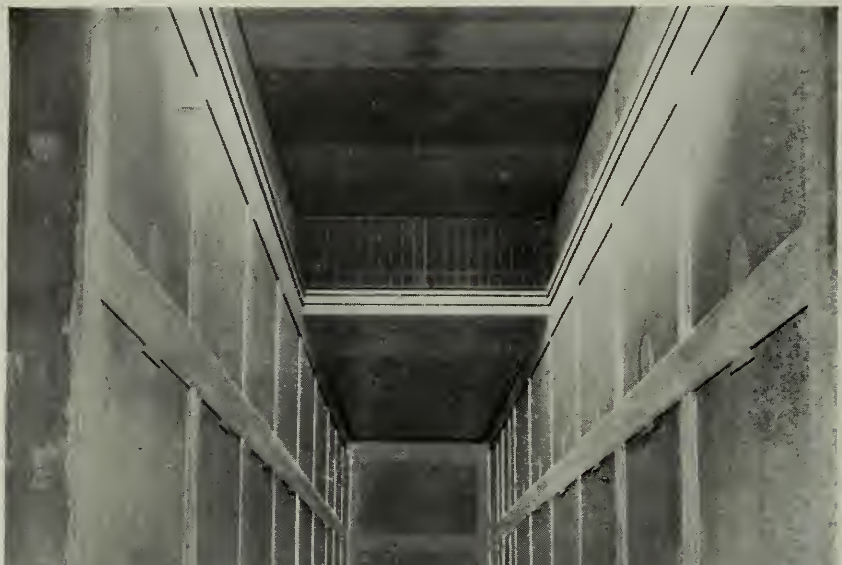
A number of cottages at Talbot's Inch are at present in course of erection with "Winget" concrete blocks.

NEW USES FOR CONCRETE
AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE WINE BINS.

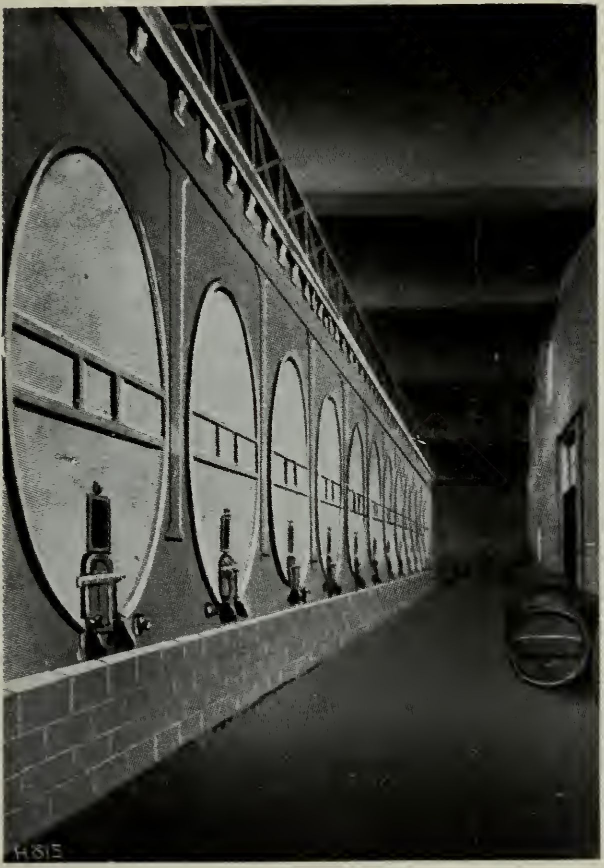
THERE have been numerous examples in France of the use of reinforced concrete for wine bins, some having been constructed of this material so far back as 1898, and the fact that the owners express their complete satisfaction with this method of construction is sufficient proof of its suitability for such a purpose.



Cellar of Reinforced Concrete Bins containing 12,500 Hectolitres.
REINFORCED CONCRETE BINS AT PERPIGNAN, FRANCE

REINFORCED CONCRETE WINE BINS.

One of the principal requirements in the construction of warehouses for storing wine is that the greatest possible amount of space is obtainable, and this requirement fulfilled by using reinforced concrete as with this method the thinnest possible walls can be made, and every available inch of space can be used. Another advantage with reinforced concrete bins is that, unlike wood, cement is non-absorbent, so that the wine is preserved exactly as it was put in.



Cellar of 16 Bins containing 6,000 Hectolitres.

Reinforced Concrete Wine Bins at Perpignan, France.

Wooden bins are treated in various ways before being filled with the wine, but the most efficacious one for reinforced concrete has been found to be by applying a solution of tartaric acid, after which the bin is well rinsed out and ready for use.

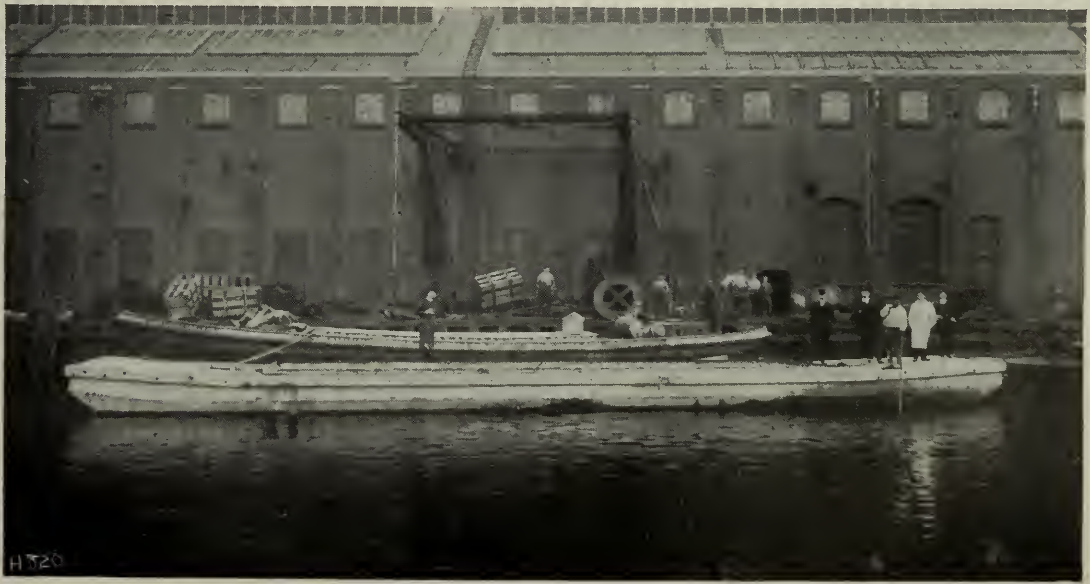
We are indebted to " Le Béton Armé " for our particulars and for the illustrations.

REINFORCED CONCRETE BOAT, AMSTERDAM.

The boat described in this article has just been launched at Amsterdam. It is constructed entirely of reinforced concrete by the Amsterdamsche Fabriek van Cementyzerwerken, who have been making boats of this material since 1887.

The boat shown in our illustrations is 62 ft. long. It was constructed under the supervision of Mr. A. A. Boon, chief engineer of the above-named company.

The width at top is 14 ft., and at bottom 11 ft., and the sides are about 2 ins. thick. The weight of the boat is 36 tons, and it has a bearing power of 50 tons.

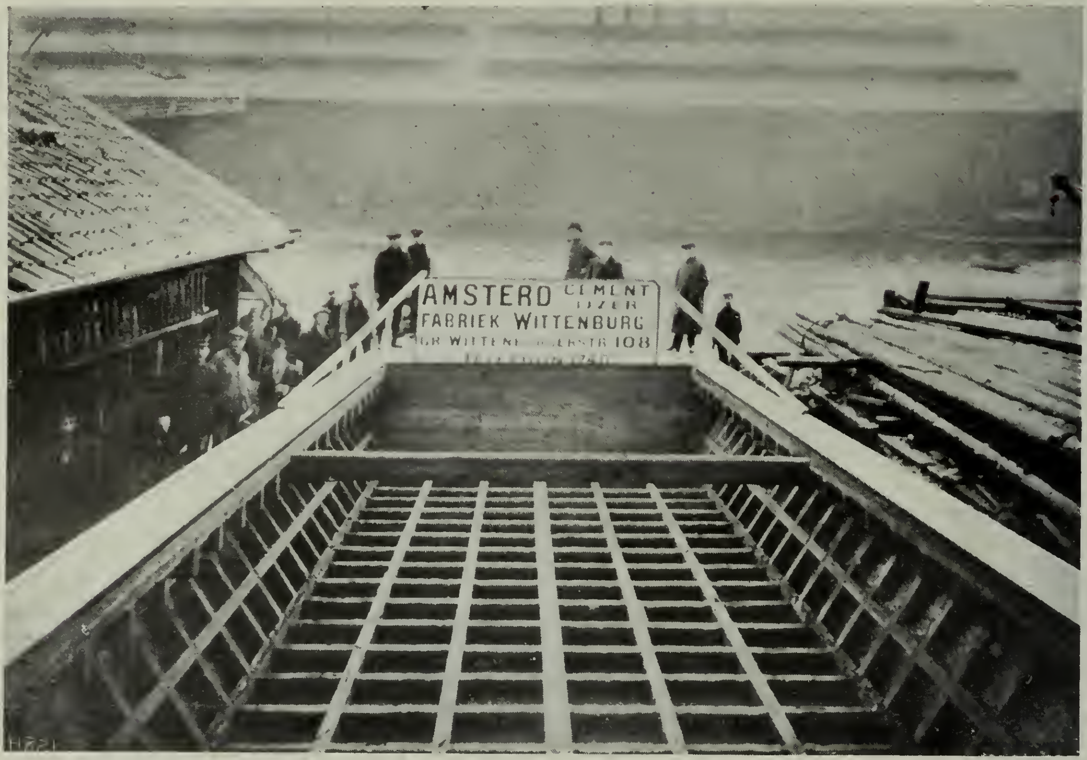


View of Boat after Launching.

Reinforced Concrete Boat, Amsterdam.

The boat is divided into three parts by cross partitions, the middle portion, which is 37 ft. long, being used for the cargo.

The measurement of the floors and beams was calculated to resist the tensile stresses caused by launching and loading. All round the boat a fender beam has been fixed.



View of Boat in Course of Construction.
Reinforced Concrete Boat, Amsterdam.

The concrete used consisted of 1 part Portland cement, 1½ parts sand, and 1½ parts gravel.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The International Testing Association.—In further reference to our editorial remarks regarding the co-operation of professional men and those concerned in the great industries of Great Britain in the work of the International Testing Association, we publish below a revised list of the members of the various standing sub-committees known as "Problem Committees."

This list indicates in the first place the problems in hand and the constitution of the committees, but at the same time it shows the lamentable paucity of the British co-operation. Unfortunately, too, of the few British delegates only quite a small proportion take that active interest that might be expected. They for the most part figure ornamentally on the committees, but avoid the hard work. It would be well if a radical change were made in this absence of co-operation and work on the "Problem Committees" before the next general meeting of the Association in 1912.

The list is as follows :

B. Hydraulic Cements, Stones, Concrete.

PROBLEM 7.—On the relation of chemical composition to the weathering qualities of building stones. Influence of smoke, especially sulphurous acid, on building stones.—On the weathering qualities of roofing slates. (Proposed at the Zurich Congress, 1895.)

Chairman of the Commission : A. Hanisch, Vienna. *Vice-Chairman :* P. Larivière, Paris.

Members : E. Dietrich, Berlin ; J. Hirschwald, Berlin ; M. Gary, Gr.-Lichterfelde ; E. Glinzer, Hamburg ; H. Seipp, Kattowitz ; A. B. W. Kennedy, London ; A. Siemens, London ; E. Leduc, Paris ; H. L. J. Vogt, Christiania ; A. Greil, Vienna ; N. Lamine, St. Petersburg ; J. Maluga, St. Petersburg ; W. Ewald, St. Petersburg ; C. Dementieff, Kiew ; A. Wikander, Göteborg (Sweden) ; Grubenmann, Zurich ; G. Lunge, Zurich ; V. Wartha, Budapest ; M. Merrimann, South Bethlehem (Pa.).

PROBLEM 50.—On the influence of the composition of the mortar and the quality of the building stone on the weathering of the masonry. (Proposed at the Copenhagen Congress, 1909.)

Chairman of the Committee : A. J. van der Kloes, Delft.

Members : van der Wallen, Brielle ; P. Joosting, Utrecht ; G. Herfeldt, Andernach ; Adams, Berlin ; Eger, Berlin ; D. Hirschwald, Berlin ; A. Hanisch, Vienna ; A. E. Munby, London ; J. Allen Howe, London ; E. Candlot, Paris ; E. Leduc, Paris ; Laboratoire méc. à l'Inst. des ingénieurs des voies de comm. (Repr. N. Belelubsky, D. Nowgorodsky), St. Petersburg.

PROBLEM 9.—On rapid methods for determining the strength of hydraulic cements. (Proposed at the Zurich Congress, 1895.)

Chairman of the Commission : F. Berger, Vienna.

Members : E. Camerman, Brussels ; D. Berg, Aalborg (Denmark) ; W. Michaëlis, sen., Berlin ; F. Schott, Heidelberg ; J. A. Ewing, Cambridge ; E. Candlot, Paris ; A. Mesnager, Paris ; R. Feret, Boulogne s/M. ; L. Bienfait, Amsterdam ; Morris, Christiania ; A. Greil, Vienna ; N. Belelubsky, St. Petersburg ; N. Bogdanoft, St. Petersburg ; Laboratoire de l'Ecole Imp. des Ingén. des voies de comm. (P. Welikhoff), Moscow ; A. Wikander, Göteborg (Sweden) ; D. v. Nagy, Budapest ; W. M. Maclay, Detroit, Mich. ; Ch. F. McKenna, New York.

PROBLEM 10.—To digest and evaluate the resolutions of the conferences of 1884—1893, concerning the adhesive qualities of hydraulic cements. (Proposed at the Zurich Congress, 1895.)

PROBLEM 11.—To establish methods for testing puzzolanas with the object of determining their value for mortars. (Proposed at the Zurich Congress, 1895.)

Chairman of the Commission : G. Herfeldt, Andernach. *Vice-Chairman :* C. Segré, Ancona.

Members : E. Camerman, Brussels ; C. van Bogaert, Antwerp ; M. Gary, Gr.-Lichterfelde ; W. Michaëlis, Berlin ; P. Wagner, Cologne ; A. Mesnager, Paris ; R. Feret, Boulogne s/M. ; J. A. van der Kloes, Delft (Hollande) ; D. v. Nagy, Budapest ; A. Czakó, Budapest ; A. Arlorio, Turin ; S. Canevazzi, Boulogne ; C. Cattaneo, Ancona ; Ceradini, Rome ; G. Giorgis, Rome ; C. Guidi, Turin ; O. Rebuffat, Naples ; A. Greil, Vienna ; H. Hillinger, Vienna ; N. Bogdanoff, St. Petersburg ; W. Czarnomsky, St. Petersburg ; E. Schwarz, Noworossisk ; A. Lundteigen, Union City (Mich.).

PROBLEM 12.—Investigation on the behaviour of cements as to time of setting, and on the best method for determining the beginning and the duration of the process of setting with special reference to ball pressure tests. (Proposed at the Zurich Congress. 1895, enlarged in conformity with the resolution of the Budapest Congress, 1901. Completed at the XXth Council's meeting, 1910.)

PROBLEM 30.—Determination of the simplest method for the separation of the finest particles in Portland cement by liquid and air process. (Proposed at the Budapest Congress, 1901.)

Chairman of the Commission : M. Gary, Gr.-Lichterfelde.

Members : A. Dyckerhoff, Biberich o/Rh. ; Kelway C. Bamber, London ; W. J. Cooper, Penarth, South Wales ; C. W. Sharrock, West Thurrock ; A Mesnager, Paris ; R. Feret, Boulogne s/M. ; Hauenschild, Beocsin (Hongrie) ; Mayntz-Petersen, Copenhagen ; Eidgenössische Materialprüfungs-Anstalt (Laboratory for Testing Materials), Zurich ; Henry S. Spackman, Engineering Company, Philadelphia (Pa.) ; O. Blaese, Wesenburg (Russia).

PROBLEM 31.—On the behaviour of cement in sea water. (a) Additional information to the reports presented at the Congress of Copenhagen, and information on the effect of sea water on Portland cement sea structures of more than 25 years' standing. (b) Study of the effect of sea water on specially prepared cements. (Proposed at the Budapest Congress, 1901, completed at the Copenhagen Congress, 1909.)

Referee to Problem (*a*) *:* E. Leduc, Paris.

Committee (*b*) *: Chairman :* E. Leduc, Paris.

Members : M. Gary, Gr.-Lichterfelde ; F. Framm, Karlshorst ; J. Bied, du Teil ; A. Poulsen, Lemvig ; W. Czarnomsky, St. Petersburg ; B. Blount, London ; A. Baykoff, St. Petersburg ; R. W. Lesley, Philadelphia (Pa.).

PROBLEM 32.—On accelerated tests of the constancy of volume of cements. (Decision of the Zurich Congress, 1895.)

PROBLEM 41.—Investigations of reinforced concrete. (Proposed at the Brussels Congress, 1906.)

Chairman of the Commission : F. Schüle, Zurich.

Vice-Chairmen : Germelmann, Berlin ; A. N. Talbot, Urbana (Ill.).

Members : W. H. Warren, Sydney ; Paul Christophe, Brussels ; E. Suenson, Copenhagen ; T. Grut, Copenhagen ; Alf. Hüser, Oberkassel (Germany) ; E. Züblin, Strassburg i. E. (Germany) ; A. Martens, Gr.-Lichterfelde; Bürstenbinder, Hamburg ; A. Dyckerhoff, Amöneburg ; Edwin O. Sachs, London ; Max Clarke, London ; W. Dunn, London ; W. C. Unwin, London ; A. Considère, Paris ; Rabut, Paris ; A. Mesnager, Paris ; R. Feret, Boulogne s/M. ; Tricon, Paris ; S. J. Rutgers, Rotterdam ; Silvio Canevazzi, Bologna ; Camillo Guidi, Turin ; Claudio Segré, Rome ; R. Norwegien Road-Departement in Christiania ; J. Melan, Prague ; B. Kirsch, Vienna ; F. v. Emperger, Vienna ; V. Brausewetter, Vienna ; N. Belelubsky, St. Petersburg ; Droujinine, St. Petersburg ; Jitkewitsch, St. Petersburg ; Boguslawsky, St. Petersburg ; Abramoff, Nowotscherkassk ; H. Hirszson, St. Petersburg ; R. Maillart, Zurich ; Richard Zielinski, Budapest ; Josef Schustler, Budapest ; A. Czakó, Budapest ; E. Turneaure, Madison (Wisconsin) ; R. L. Humphrey, Philadelphia (Pa.).

PROBLEM 42.—Uniform tests of hydraulic cements by prisms and determination of a standard sand. (Proposed at the Brussels Congress, 1906.)

Chairman of the Commission : F. Schüle, Zurich.

Members : Laboratoire des Ponts et Chaussées, Boulogne s/M. (R. Feret) ; Laboratoire des Ponts et Chaussées, Paris (A. Mesnager, Mercier) ; Laboratoire du Conservatoire des Arts et Métiers, Paris (Leduc) ; Kgl. Material-Prüfungsamt, Gr.-Lichterfelde (A. Martens, M. Gary) ; Laboratorium des Vereines deutscher Portland-Zementfabrikanten, Karlshorst bei Berlin (Framm) ; Eidgenössische Material-Prüfungsanstalt, Zurich (Schüle) ; Laboratoire méc. de l'Institut Imp. des voies de comm., St. Petersburg (N. Belelubsky, D. Nowgorodsky) ; Mechanisch-technisches Laboratorium der technischen Hochschule, Wien (B. Kirsch) ; Dänische Staatsprüfungsanstalt in Copenhagen (Mayntz-Petersen) ; Ecole d'applications pour les Ingénieurs, Bologna (S. Canevazzi) ; Laboratoire de l'Arsenal de l'Etat Belge, Malines (E. Camerman) ; Material-Prüfungsanstalt von Bienfait & Koning, Amsterdam (L. Bienfait), R. L. Humphrey, Philadelphia (Pa.) ; D. v. Nagy, Budapest ; A. Czakó, Budapest ; C. Zielinsky, Budapest ; C. H. Desch, Glasgow ; H. Kelway C. Bamber, London ; R. T. Glazebrook (National Physical Laboratory), Teddington ; C. Watson, Greenhithe ; G. Pfeiffer, Bucarest ; R. Frey, Luterbach (Switzerland) ; N. Abramoff, Nowotscherkassk.

Bridge at Great Boughton.—The Stokesley R.D.C. have instructed the surveyor to prepare an estimate for a reinforced-concrete bridge and alternatively for one with stone piers and iron girders.

Piles at Aberdeen Harbour Works.—Considère patent piles are being employed in connection with the scheme of new wharves in course of construction at the Aberdeen Harbour works. The piles are 56 ft. to 58 ft. long, 1 ft. 4 in. in diameter, and are driven through clay to a depth of about 50 ft. They are driven until they stand seven blows of the hammer without penetrating more than 1 in. About 700 of these piles are being used in connection with this work.

Newport Bridge.—After considerable discussion as to whether the existing bridge at Newport should be widened or whether a new bridge should be erected, the sub-Committee of the Newport Corporation in charge of this matter, at their last meeting, decided to recommend that a new bridge be erected on the site of the present bridge, and to recommend that the new structure should be of reinforced concrete.

A Reinforced Concrete Bandstand at Wiesbaden.—A bandstand recently built in the Kurhaus Gardens at Wiesbaden consists of a platform covered by an arched roof in the form of a semi-dome, the entire structure having been built of reinforced concrete in six weeks. The stand covers an area measuring about 47 ft. by 38 ft., and the semi-circular arch in front has the span of 40 ft. clear. One notable advantage secured by the material employed and the arched form adopted is the excellent acoustic effect, and it is stated that the carrying power of the instruments is particularly marked.—*Engineer.*

The Action of Mine Water on Concrete.—The action of mine water on concrete has been under observation for some years by Mr. R. D. Richardson, concrete engineer for the Coal Mining Department of the Delaware, Lackawanna & Western Railroad, and as a result he has concluded that dense concrete made with proper materials will not be affected by mine water of the quality found around Scranton, Pa. This water, in the only analysis made, showed ¼ per cent. of sulphuric acid. It should be understood, however, that this conclusion is based on observations of concrete not subjected to abrasion, and might not apply, for instance, to the concrete in the inclined bottoms of coal pockets. The water analysed comes in contact with a reinforced concrete dam, and after three years of service the acid has had no deteriorating effects. Mr. Richardson has immersed small blocks of dense concrete, having a piece of steel embedded in them, in mine water for fifteen months. When broken the metal was as bright as it was the day the blocks were made. Several instances have been noted of the destruction of concrete by mine water, but Mr. Richardson states that this was due to the porosity of the concrete and to the poor materials, slate and "bony," a flinty slaty rock, which were used. Slate and "bony" deteriorate rapidly under the action of mine water. The company has a number of concrete coal pockets which have not been emptied for a long time, and consequently it is not known how the abrasion combined with acid water is affecting the concrete, but the concrete appears to be in good condition.—*Engineering Record.*

A Concrete Statue.—Above Eagle's Nest, in the state of Illinois, a large statue has been erected in concrete in memory of Blackhawk, the famous Indian chief. The statue is 48 ft. high, exclusive of the artificial base or the natural rock foundation on which it is placed. It is claimed that this statue will probably last for ever, and it is a magnificent example of mechanical genius and engineering skill.

Inspection of Concrete.—It is time, says *The Sanitary Record*, that the general public became possessed of the idea that there is good and bad concrete. People should learn to distinguish the different grades of concrete. Just as there are first and second classes of masonry, brickwork, woodwork, or steel construction, so there are different grades of concrete work.

Too frequently people look upon concrete as concrete, and attribute qualities to it which in the particular instance it does not possess. Concrete does possess many excellent qualities, but careful, systematic inspection is an absolute necessity.

Concrete and reinforced concrete construction have proven their worth, and their wide usage is proof of their acceptance. The wharves on the sea coast, the

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immense piers under railway bridges, the massive dams of hydro-electric plants, the irrigation dams and canals on the prairie, and the pavements and foundations of the cities all attest the merits of this material.

Good cement, good sand, and good gravel will not make good concrete unless properly handled, and inspection is just as necessary in the handling of the material as in its selection. Yet inspection of concrete is not so difficult as the inspection of steel. Almost any inspector of a concrete building can tell by looking at the concrete as it goes into the forms whether it is good or bad, and whether or not the specifications are being lived up to. There are certain simple requirements in the making of concrete, and, if these are attended to, the place or method matters little.

It is in the execution of the work, however, that the inspector has to show greatest care, and, although the inexperienced workmen are growing less and less as more concrete is being executed, yet some workmen and contractors require constant watching. More failures of concrete have occurred traceable to inexperience than to any other cause. Forms are built incorrectly, insufficiently clean, and frequently no judgment is used in removing.

Concrete Sewer Pipes for Folkestone Road Drainage Works.—In connection with the works of surface-water drainage shortly to be commenced here, a new industry has made its appearance in Dover—namely, the manufacture of the rock-concrete tubes that will be required for these works.

The manufacture of sewer pipes of concrete was first introduced into England in the year 1875 by Messrs. Sharp, Jones & Co., of Bourne Valley Pottery, Parkstone, Dorset, but sewer pipes of that material had been in successful use in the United States for over forty years previously.

Their manufacture in England partook at first of the nature of the utilisation of a waste product—viz., the "shards" from Messrs. Sharp, Jones & Co.'s extensive stoneware-pipe works. But the use of rock concrete tubes rapidly outgrew the limited supplies of this "aggregate," and for many years past the tubes have been made from the exceptionally dense granite found in the Channel Islands, so well known as Guernsey granite. It is of this material, together with Portland cement, specially prepared for them on the Thames, that Messrs. Sharp, Jones & Co. are making the pipes to be used in Dover. The sizes range from 27 in. internal diameter up to 48 in., the rock-concrete tubes of the last-named size weighing nearly one ton each, and of these some 600 will be required. The new factory is well equipped with modern machinery and appliances, and the motive power required is drawn from the Corporation's electric power mains.

Although rock-concrete tubes are primarily intended for the construction of sewers and covering in of streams, they are, owing to their imperviousness to water, constantly made use of as well-linings and for tanks. They have also been used in Dover by the Royal engineers for sewer manholes, and for the same purpose at the new Duke of York's Schools, and at Walmer and Canterbury, besides being used for sewers in various Kentish towns.

CORRESPONDENCE.

Coke Breeze Again.—SIR,—In an editorial with the above title, in the April number of CONCRETE, you say that it is as senseless to condemn an excellent material because in a few instances poor stuff has been used as it is to condemn reinforced concrete because the material is not invariably properly applied, and you quote my remarks on this point in my paper read before the Concrete Institute in December.

But you do not state—nor has any building paper, I believe—that in the discussion that followed Sir Henry Tanner said he had used coke breeze for floors for the past twenty years, and had received no complaints in connection therewith.—Yours faithfully, THOMAS POTTER.

The Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

TRADE NOTICES.

The "Tenet" Reinforcing Bar.—We have received particulars of a new reinforcing bar for concrete called "The Tenet." This bar has shear members inclined at about 45 or 50 degrees to the main rim of the bar and is so constructed that when built into the concrete it forms a complete truss.

A rigid bond is provided in the bends at the top and bottom of the shear members for the natural bonding of the concrete to the steel. The action of the inclined members is made positive with the main bar by a locking device with the concrete between the loops at right angles to the main bar. This action with the main bar is further strengthened by a locking contact of the main tie, which renders the reinforcement rigid and complete. One of the special advantages of this bar is that the shear and tension members are in one piece, and the steel in the former, being double, gives an excellent hold to the concrete.

The inventor claims that, from the manner in which the shear members are formed with the main bar, it is impossible for any slipping of the bar in the concrete. For full particulars and illustrations of this bar apply to Mr. J. F. Cowper, of 23 Strutt Street, Manchester.

The Perfector Buildings and Constructions, Ltd., inform us that 5 Coney Street, York, hitherto known as the northern offices of the Perfector Buildings and Constructions, Ltd., has now been taken by Mr. W. Harvey Brown, Architect and Consulting Structural Engineer, specialising in factory and school construction. Enquiries and correspondence intended for the Perfector Co. should be addressed to the Registered Offices at 36–38 Victoria Street, Westminster, their engineering and construction offices, or to 1 St. Augustine's Parade, Bristol, or sent to their local agents.

CONTRACTS.

Messrs. Stuarts Granolithic Co., Ltd., inform us that the following contracts have recently been placed with them :—

Large Silo Construction and Granaries at Immingham, for the Great Central Railway ; Carbisdale Castle, Ross-shire, for the Dowager Duchess of Sutherland ; Brewery and Stores Extension at Glasgow and at Bristol, for Messrs. Whitbread ; Floors and Roofs for the New Criminal Lunatic Asylum at Rampton, for the Home Office ; Extensive Retaining Walls and Buildings at Rosyth, N.B., for the Admiralty ; The Eye Hospital, Nottingham ; Seed Silos at Trafford Park, Manchester ; Grain Silos at Barry, for Messrs. Rank ; New Hostel and Training College, Crewe, for the Cheshire Education Committee ; New Secondary Schools at Bromsgrove, Worcestershire ; Additional Blocks of Buildings at Bordesley, Birmingham, for H.M. Office of Works ; Freemasons' Hall, Edinburgh, etc., etc.

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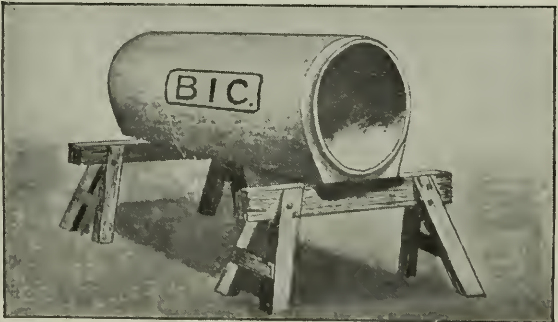

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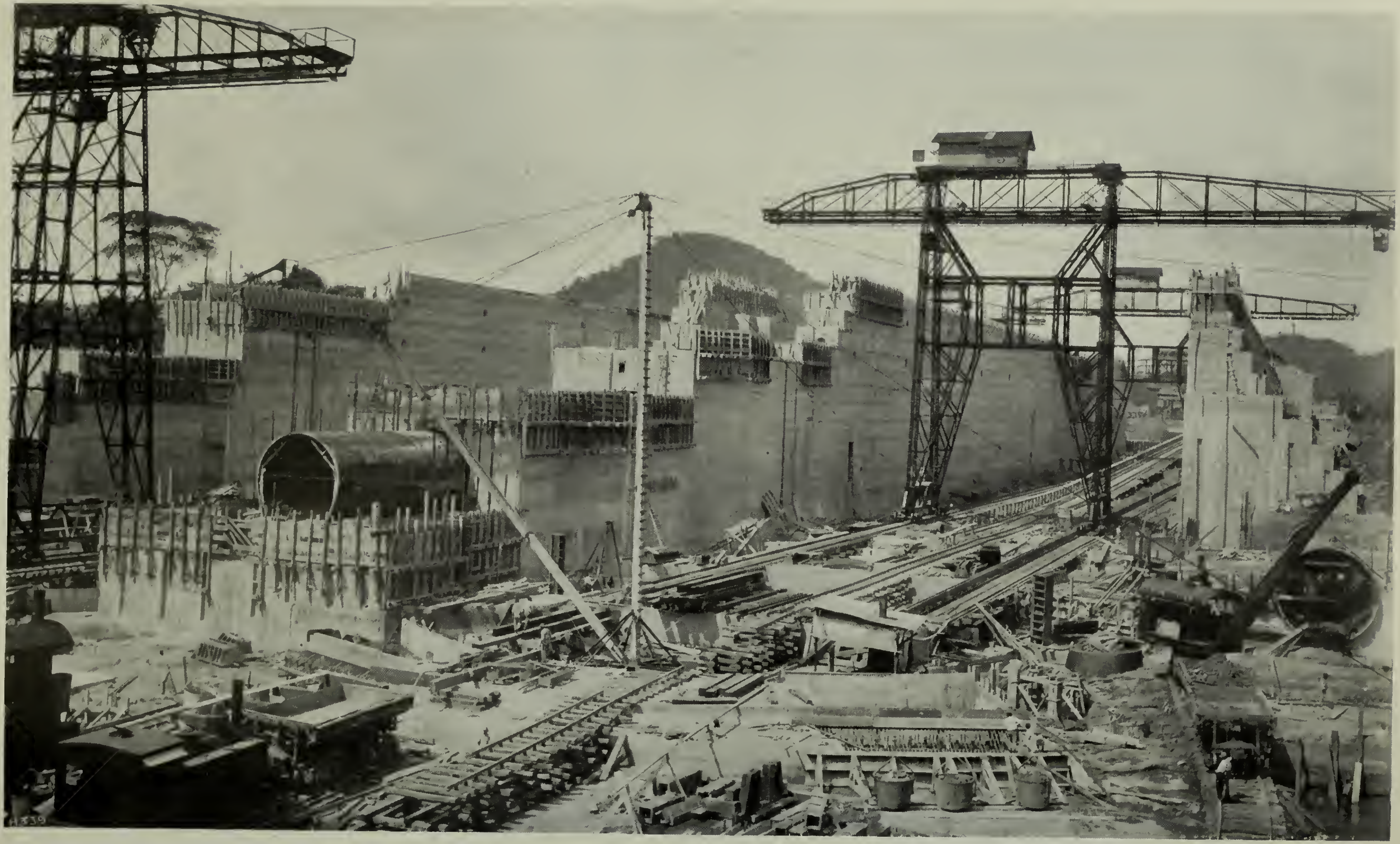


Pedro Miguel Locks.
Concrete Construction in the Panama Canal.

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume VI. No. 6. LONDON, JUNE, 1911.

EDITORIAL NOTES.

THE NEW LONDON DOCKS AND WAREHOUSES.

THE Dock and Warehouse scheme of the London Port Authority, which is to give the Metropolis the shipping facilities it has so long required, appears to have been admirably conceived, and if there is any one weak spot in the programme put forward, it is only to be found in the time-table of the proposed works, which, to our mind, should be greatly accelerated. Not only do the actual requirements of to-day call for celerity, but we have to be prepared to meet the impending greater competition of Antwerp and Hamburg, and years—nay, months—will count if we are to be successful in making up the leeway of past years and in obtaining a lead for the future.

THEIR PLANNING AND CONSTRUCTION.

In one direction the proposed works of the London Port Authority especially interest us at the moment. We should like to see some memorandum issued as to the precise character of the warehouses and sheds to be erected, both as regards plan and construction. Such enormous strides have been made of late years—more particularly at Hamburg—in efficient warehouse building that we would welcome some indication of a change from the old style of warehouse we know to something more effective and safe. As to safety in particular, the greatest possible forethought is necessary, for not only does a reduced absence of fire risk tend to popularise a port, but it often brings with it a material reduction in fire insurance premiums, a matter of no small importance in these days where a saving of pence may bring, or divert, thousands of tons of merchandise.

THEIR FIRE-RESISTANCE.

The new warehouses and sheds should be most carefully planned with the view of limiting the risk of an outbreak of fire spreading over the least possible area, and the construction should be such that it is truly fire-resisting, and not "fire-proof" only in name. Concrete, steel frame well protected by concrete, and reinforced concrete if so designed as to fully meet the fire risk, are all materials and systems of construction that should find favour in the new warehouses and sheds, and a word of warning should here be immediately said—namely, that if metal work is not properly protected by concrete, or by brick bedded in cement, the steel framing or steel rods are a source of danger.

We have seen reinforced concrete warehouses at Brussels where the metal rods had but a covering of $\frac{1}{8}$ in., and were practically visible. We have noticed reinforced concrete "entrepôts" at Antwerp with a uniform protection of but $\frac{1}{4}$ in. to $\frac{1}{2}$ in. to the metal rods. We have before us particulars of fires in warehouses at Marseilles and Alexandria, where reinforced concrete played a considerable part, but unfortunately not a very successful one owing to the absence of elementary precautions.

On the other hand, we have seen excellent warehouse work at Berlin and Hamburg, where the reinforced concrete in every way meets modern fire requirements, and have before us particulars of several fires where reinforced concrete of good design and execution afforded an excellent fire-stop.

Thus, with such lessons before us, we would press for special forethought in the selection of materials and systems of construction in the new warehouses and sheds of the Port Authority, so that good materials may not be discredited by unsuitable application or unsatisfactory materials applied without due protection. On the fire hazard of the new London docks and sheds much will depend economically, and we are advised that a reminder in this direction may not be out of place.

CONCRETE AND FIRE-RESISTANCE.

Since the institution of this journal we have frequently had occasion to point out the advantages of using concrete where fire protection is desired. We have now before us some tables issued by the British Fire Prevention Committee in which the results are given of the official fire tests conducted by the Committee in respect of some twenty-eight floors, and no better testimony could be afforded to the utility of concrete as a fire-protective material.

The tables, it should be said, form part of a series which the Committee are preparing with a view to summarising the results of various forms of official fire tests that have taken place at their testing station during the past twelve years, and we look forward to seeing the tables that are about to be issued regarding partitions, for we recollect that a number were constructed either in part or wholly of concrete.

The committee's "Red Books" dealing with individual partitions, just as their "Red Books" dealing with individual floors, are no doubt of the highest value; and in each case give full particulars of the occurrences during a fire test, supplemented by drawings and photographs. The tables that we have before us, however, now afford the best material for arriving at a prompt and definite conclusion as to the relative merits of different materials and methods of construction, and it is matter for congratulation that the labour and expense of publishing the results of so many years of inquiry should have been incurred so that these valuable data may now be so easily referred to.

THE RESULTS OF TWENTY-EIGHT FLOOR TESTS.

Of the twenty-eight floors tabulated, four are purely timber floors, and these do not particularly concern us, although it should be remarked that the hard woods such as oak, karri and jarrah afford considerable protection. Several floors are composite timber and concrete construction. Here the advantages of concrete for the purposes of pugging are manifest, particularly in one case where the pugging has been taken down to 2 in. below the timber joist, thus affording a protection to the wood.

Turning to floors of steel frame and concrete we find most excellent results, notably in the cases where concrete has been taken around the steel framing to the extent of 2 in. In fact, 2 in. seems to be the practical minimum of protection that should be accorded to steel framing where fire protection is desired.

The concrete floors dealt with in the report, be they of the Expanded Metal type, the old Columbian type, or of the Skelton type, are infinitely more superior, more simple and more economical than anything else brought forward from the fire point of view, and the reinforced concrete floors tested—namely, those of the Coignet type and the Indented Bar type—each make most excellent showing. Only in two instances, to which we have referred in an earlier issue, did reinforced concrete not come up to what is expected of it, and this was purely owing to the absence of affording proper protection to the metalwork. One of these cases was that of the Visintini hollow floor, with only a half-inch to three-quarter inch cover to the rods and where the protection thus afforded to the metalwork was entirely inadequate, and a collapse resulted, but the lesson taught by this particular floor was learned not only at home but also abroad, and it is unlikely that such errors will be repeated except by those grossly ignorant or negligent.

Altogether, nothing could have been more timely, particularly with the fires in the reinforced concrete warehouses at Marseilles and Alexandria, than the issue of these tabular results, and should arguments ever be raised that reinforced concrete is unsuitable from a fire-protective point of view there is no doubt that these tables clearly bear out that, if sufficient protection is afforded to the metalwork, and suitable aggregates are carefully applied, no better form of protection can be desired from the fire point of view.

REINFORCED CONCRETE AS A SAFEGUARD IN MINES.

THIS journal has frequently dealt with the advantages of using reinforced concrete in mines, and more particularly in mines subject to the danger of fire and explosion, such as coal mines. The introduction of reinforced concrete was advocated by us as far back as 1906, and at that time our critics considered our views all too *ex parte* and premature. Gradually, however, professional opinion has commenced to favour the new material. In the United States, in Germany, and in France its introduction has made some progress, and with the sad mine disaster of last year the compulsory use of the material in new works is under consideration.

The Home Office Enquiry on the Pretoria Pit disaster shows us that Mr. R. A. Redmayne, M.Sc., the Chief Inspector of Mines, has not lost sight of the matter, and a question of his addressed to Professor Galloway claims attention, having regard to the reply of the last-named eminent authority. We thus reproduce question and answer, and would again call the attention of our readers to the advantages of reinforced concrete in coal mines.

> ***Mr. Redmayne:*** In view of possible precautions in respect to coal dust—as you know, we are feeling our way in the matter—the question of zones is very properly occupying the minds of mining men. I would very much like to have your views on that point, first of all as to the possibleness of zones of different kinds, such as swept zones, damp zones, or zones of adulteration by stone dust, and the use of reinforced concrete or arching where you place these zones. What I have in my mind is a means of preventing a possibly small and comparatively harmless condition of fire damp at the face becoming an extensive explosion.

Professor Galloway: Well, undoubtedly, if zones were long enough they would prevent the spread of an explosion, but it has not yet been shown experimentally what length the zone would require to be. In comparatively small experiments at Altofts a zone of 50 ft. appears to have been appreciable. It depends very greatly on the distance the explosion has already travelled, and on the force behind it. The only places where the zones could be comparatively short would be near the face.

STORAGE OF CEMENT.

It is not generally recognised how quickly the finely-ground cements of to-day are depreciated by storage of the ordinary kind on works. Cement is usually received on a job packed in sacks, and is very often obtained in large consignments, and has to be stored on the works. Sheds are provided, generally of flimsy construction, which offer plenty of opportunity for the passage of air through them, being built, for instance, of boards, the joints of which are fairly open. The moist air that passes through the storage sheds gets taken up rapidly by the finely-ground cement, which cakes, and one finds after a short while the outside portions of the sacks to be quite hard. This is often aggravated on works near any water-logged soil, or in connection with bridges, the covering over of a stream with a culvert and such-like, by the erection of a shed with boards nailed to upright posts just stuck in the ground and without any proper floor, the cement being merely stacked on open boards laid direct on the ground. In some cases the cement has been stored for the winter in such situations. Of course, there is every opportunity of moist air being in association with the cement, which naturally depreciates with great rapidity, and in a week or two loses half or more of its strength.

The old clause which was inserted in specifications in the past, requiring the cement to be stored in thin layers and turned over from time to time, was distinctly advantageous with the coarsely-ground cement which was the custom in the earlier period of manufacture, and which frequently contained free lime, but the cement of to-day is entirely different, and it requires a different treatment. The finer ground a cement is, of course, the better it is, and therefore we see the foolishness of storing the modern cement for some time before usage. If, as often must be the case, the cement is to be taken in large consignments, then it should be stored in air-tight bins—that is to say, compartments into which moist air is not permitted to pass; but in most cases it is possible to arrange the consignment so that the cement is used while fresh, very shortly after it is received from the manufacturer. The product sent out by the manufacturer is good enough for use straight away.

We require the cement to give us a strong concrete—that is to say, strong in compression—and, as we have said, the storage for a few weeks can only result in reducing the strength of the concrete to perhaps a half, and that means that we are losing 50 per cent. of value. The importance, therefore, of speedy usage or proper air-tight storage of cement is obvious.

REINFORCED CONCRETE FOR THE BUENOS AIRES PORT EXTENSION.

We desire to congratulate Messrs. Edmond Coignet, Ltd., and their able officers, Messrs. Workman and Béhar, on the magnificent contract for reinforced concrete obtained by them under the general contract entered into by Messrs. C. H. Walker & Co., Ltd., for the Argentine Government.

To be precise, a decree was signed at the end of April by the Argentine Government awarding the contract for the New Port Works, Buenos Aires, to Messrs. C. H. Walker & Co., Ltd., engineers and contractors of London, the total amount of the contract being about £5,500,000. The work involves the reclamation of over a million square yards of land, the construction of four new docks, with quays extending for over 5,000 lineal yards, and warehouses covering about 100 acres of floor space. The engineers for the general scheme are Messrs. Livesey, Son & Henderson.

In order to give an idea of the importance of the reinforced concrete portion of the work, we may state that it is anticipated that about 154,000 cu. metres of concrete will be required, and no less than about 19,000 tons of steel. The total scheme includes 14 large warehouses, 20 sheds, 80 subways, uniting the various warehouses and sheds, and a certain number of large grain silos.

This is probably the largest contract ever secured in reinforced concrete.

The reinforced concrete scheme was prepared by Messrs. Edmond Coignet, Ltd., of London, and the buildings are to be executed entirely in this material, including walls, roofs, staircases, and loading platforms.

The following are some details of the various structures which are to be executed on the Coignet system :

(*a*) There are to be six warehouses 126·20 metres in length by 36·20 metres in width. Facing these, two transit sheds have been provided for each warehouse, there being a total of twelve sheds in all, having a length of 108·10 metres by a width of 29·9 metres each.

(*b*) In addition to the above buildings the scheme provides for eight warehouses of a length of 108·10 metres and a width of 21 metres, and each of these warehouses has an adjoining shed of the same dimensions as the other twelve sheds mentioned above.

(*c*) The various warehouses and transit sheds are to be united by underground passages entirely in reinforced concrete. The total length of these passages will be approximately 1¼ mile.

(*d*) The first-mentioned warehouses are composed of a ground floor, with basement, first, second, and third floors, and a flat roof.

(*e*) The sheds are composed of a basement, ground floor, first floor, and flat roof.

(*f*) The basements of the various buildings are formed by retaining walls in reinforced concrete.

(*g*) In addition to the transit sheds and warehouses, the scheme provides for two transit silos having a total storage capacity of approximately 20,000 tons of grain. Each silo is to be divided up into a certain number of storage bins.

The above describes the scheme as tendered for by Messrs. C. H. Walker & Co., Ltd., but the Government reserve to themselves the right to make any modifications that they may find advisable.

LOAN PERIODS FOR REINFORCED CONCRETE WORK.

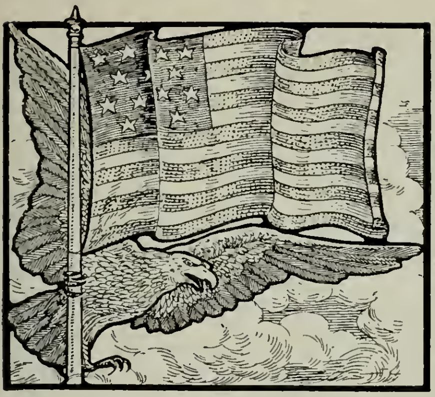
We have often referred to the unfair treatment reinforced concrete receives at the hands of the Local Government Board when municipal authorities apply for loans. It therefore affords us some pleasure to be able to state that a 30 years' loan period has just been granted for some new lavatories and a shelter, which have been designed for the Bridlington Corporation by Mr. Ernest R. Matthews, Assoc.M.Inst.C.E., the borough engineer of that locality. The reinforced concrete in question amounts to a value of about £700, and comprises retaining walls, roofs, and steps. We are informed that this is reinforced concrete proper, as distinct from steel framing and concrete, and if this is so we believe this must be one of the first cases, if not the very first, in which reinforced concrete work has been accorded the full 30 years' loan period generally given on other materials. The matter is certainly one for congratulation, as it affords a precedent, and may assist in bringing to an end the extraordinary treatment reinforced concrete has had up to the present at the hands of the Local Government Board.

REINFORCED CONCRETE BRIDGES OVER THE THAMES.

In our issue of December, 1910, we called the attention of the Corporation of the City of London to the claims of reinforced concrete when considering the design for their new bridge over the Thames. The question of constructing several bridges over the river is now having attention, and we would, as in the case of the Corporation, also remind the London County Council of the advantages of the new material.

What holds good for the River Thames applies to quite a number of other rivers in the United Kingdom, and we can only mention that, even for bridges of considerable span, reinforced concrete has been found eminently preferable and economical on the continent of Europe and in North and South America. Mere conservatism should not limit the question of bridge design to steel frame or to masonry. Reinforced concrete has proved itself highly efficient, and the reduction in maintenance charges by the use of this material should be remembered.

Reference to former issues will show excellent examples of reinforced concrete bridge-work, and in the current number some further illustrations of structures of this description are again presented.



CONCRETE CONSTRUCTION IN THE PANAMA CANAL.

II.

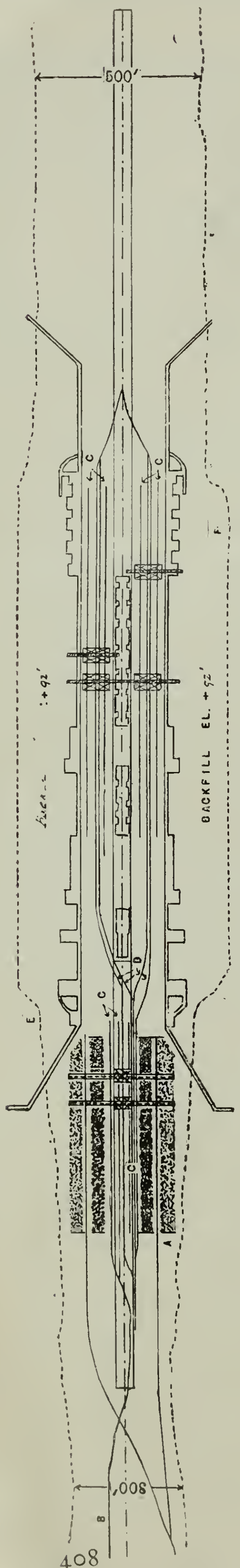
By JOHN GEO. LEIGH.

The construction of the Panama Canal is certainly one of the greatest engineering feats ever accomplished, and we feel sure that an account of the concrete work in this great undertaking will interest our readers. We are therefore devoting three articles to it, and the third instalment will appear in our July number.—ED.

Concrete Handling at the Pacific Locks.—The plant used for placing concrete in the two flights of locks on the Pacific slope differs essentially from that in operation at Gatun, and consists primarily of eight cantilever cranes of two types, designated respectively, berm and chamber cranes. The high and unstable banks flanking the Pedro Miguel site made it necessary to develop the handling plant in a longitudinal direction, by placing storage trestles and mixing machines in the lock forebay, and introducing a narrow-gauge railway for transporting the mixed concrete to the placing, or chamber, cranes installed in the lock-chambers themselves.

At Miraflores, however, the operation is considerably simplified, as the nature of the ground permits of the placing of the storage piles and mixing machines on both sides of the lock pit and of the consequent disuse of any transporting railway. The lay-out of the plant in each case will be found clearly indicated in *Figs.* 11 and 12. In the Miraflores plan, it should be noted, the distances east and west of the locks have been slightly exaggerated in comparison with the longitudinal scale, with a view to the avoidance of possible confusion between the lay-out details and the future dams.

Berm Cranes at Pedro Miguel.—The Berm cranes (see *Fig.* 13) are equipped with double fixed cantilevers, 150 ft. long, and are 62 ft. 6 in. high from the top of the rails to the bottom of the cantilever, and 90 ft. high to the top of the machinery house. The towers carrying the cantilever arms are 40 ft. by 50 ft., supported by two box girders, each carried on 16 axles. The truss in the upper part of the tower supports the operating machinery, the house enclosing it, and, in conjunction with the cantilever arms, the underhung trolley rails used for conveying the sand and crushed rock. There are two trolleys to each crane, each carrying a 2½ cu. yd. excavating bucket of the clamshell type, which supplies sand and crushed rock from the storage piles extending along each side of the forebay directly beneath the outer ends of the cantilever arms. Each trolley has a rated capacity per hour of 50 cu. yd. of sand and 100 cu. yd. of crushed rock delivered to the bins. In each tower are four bins—two for sand and two for crushed rock, each of 15 cu. yd. capacity, and so arranged that the buckets will discharge from them without overlapping in their travel.



A. Sand and Rock Storage Trestle. B. Cement Track. C. Crane Track. D. Narrow Gauge Tracks.

Fig. 11. Layout of Concrete Handling Plant for Pedro Miguel Lock.

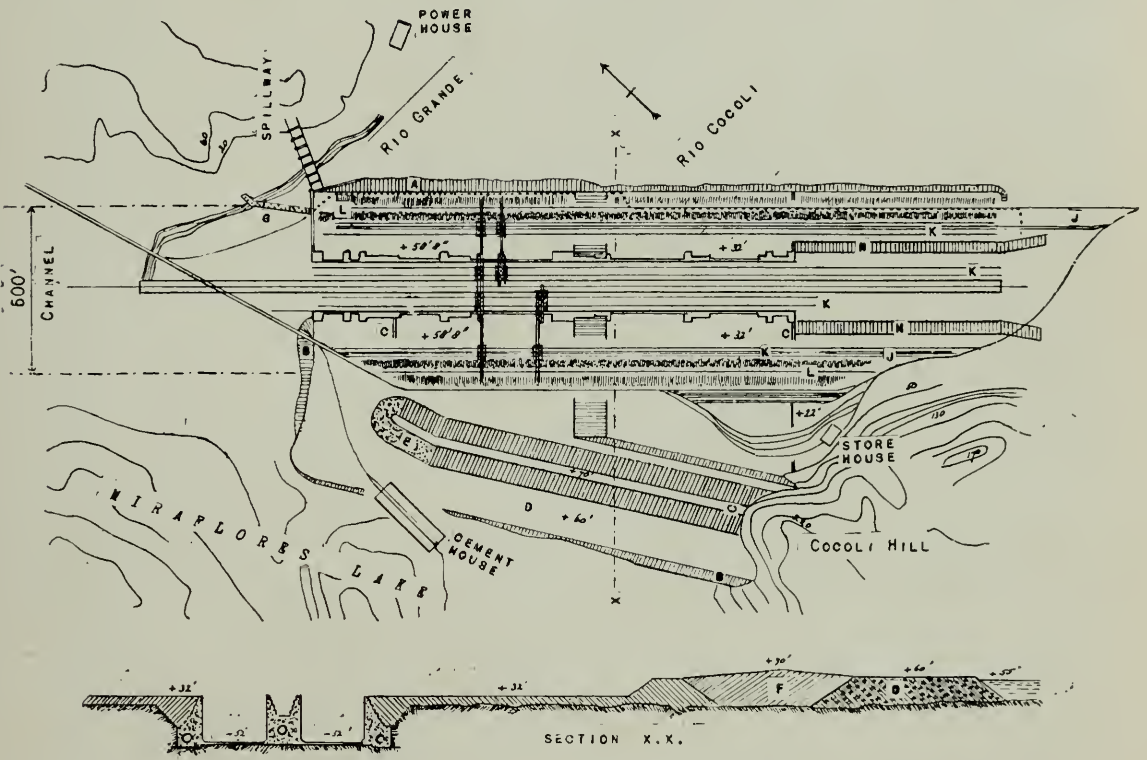
Beneath the rock and sand bins is a housed-in platform, where the bags of cement are opened and emptied into hoppers. The cement is transferred from box cars to the platform by means of an elevator and conveyor at the rate of 800 bags an hour. The elevator is operated on a set of cogs in conjunction with the conveyor, and is fitted with lifts about 3 ft. apart, each capable of holding two bags. When the bags reach the floor of the platform, they are dropped on the conveyor for transportation to bins on the opposite side; and in course of transit two men sever the strings and place the bags in a position convenient for ready handling by the men who empty them.

The measuring hoppers, which supply the concrete mixers, are placed directly below the cement platform. Each contains three compartments — for sand, crushed rock, and cement respectively—into which chutes lead from the storage receptacles above. In the tower bases are two cube concrete mixers, each of 2 yd. capacity, which discharge into 2 cu. yd. buckets carried, two on each car, on narrow flat cars. The operators on the mixer platforms control the discharges by means of compressed air, and also work the chute doors which admit the raw material into the mixers from the measuring hoppers. Water is fed into the mixers from automatic measuring tanks installed in the towers; and, in one of the cranes, an instrument, operated by electric contact, records the time consumed in each mixing operation, and also that occupied in dumping into the concrete buckets.

Chamber Cranes.—The chamber cranes (*Fig.* 13) were mainly designed to place the concrete in the lock walls; but are also used extensively in transferring the wood and steel forms from one point to another. Each crane is 97 ft. 6 in. high from the top of the rail to the bottom of the cantilever, and 115 ft. high to the top of the machinery house. The tower measures 56 ft. by 46 ft., and is supported by four heavy trucks which travel on rails extending through the lock chambers. There are two cantilever arms to each tower — one extended towards the centre wall with a length of 53 ft. 6 in., and the other, 81 ft. 6 in. long, passing over the side wall. These arms, together with the tower trusses, support a continuous runway of rails 191 ft. long.

The buckets handled by these cranes are of the double-leaf drop-bottom type, and have a capacity of 2 cu. yd. each. The four chamber cranes which have been in operation at Pedro Miguel were designed to pick up the buckets, deliver them to the lock wall, dump their contents, and deliver the empties to the cars at a combined average rate of 320 cu. yd. of concrete an hour.

Crane Arrangement at Miraflores.—Owing to the progress of work at the Pedro Miguel locks, it has been found possible to dismantle two of the cranes which have been employed there, and to re-erect them with modifications for service at Miraflores. Here the chamber cranes continue to perform the functions already described, but in the case of the berm cranes the position and method of operation are altogether different. Each crane of the Miraflores type (see *Fig.* 15) has a single cantilever arm extending over the storage pile, the place of the other arm, on the side nearest the locks, being taken by a swinging boom, 144 ft. in length, so hung that it may be operated under full load in a horizontal position ; in a position inclined 15° below the horizontal, or in a position inclined 10° above the horizontal, the last-mentioned being required for filling the top courses, or lifts, of the lock walls. This boom may be raised and lowered to provide clearance in passing the chamber cranes, and can be made to swing through a horizontal arc either side of the centre, so that the other end has a movement of 50 ft.



A. East Dam (concrete)
B. Rock Toe of West Dam
C. Concrete Core Wall
D. Rock Fill
E. Riprap
F. Hydraulic Fill
G. Protection Pier (Rock Fill)
H. Paved with Concrete (1:1 Slope)
J. Cement Track
K. Crane Tracks

FIG. 12. MIRAFLORES LOCKS, DAMS, AND CONCRETE HANDLING PLANT.

The operation of the cranes along the banks of the lock dispenses with the transportation system necessary at Pedro Miguel ; one excavating bucket operated

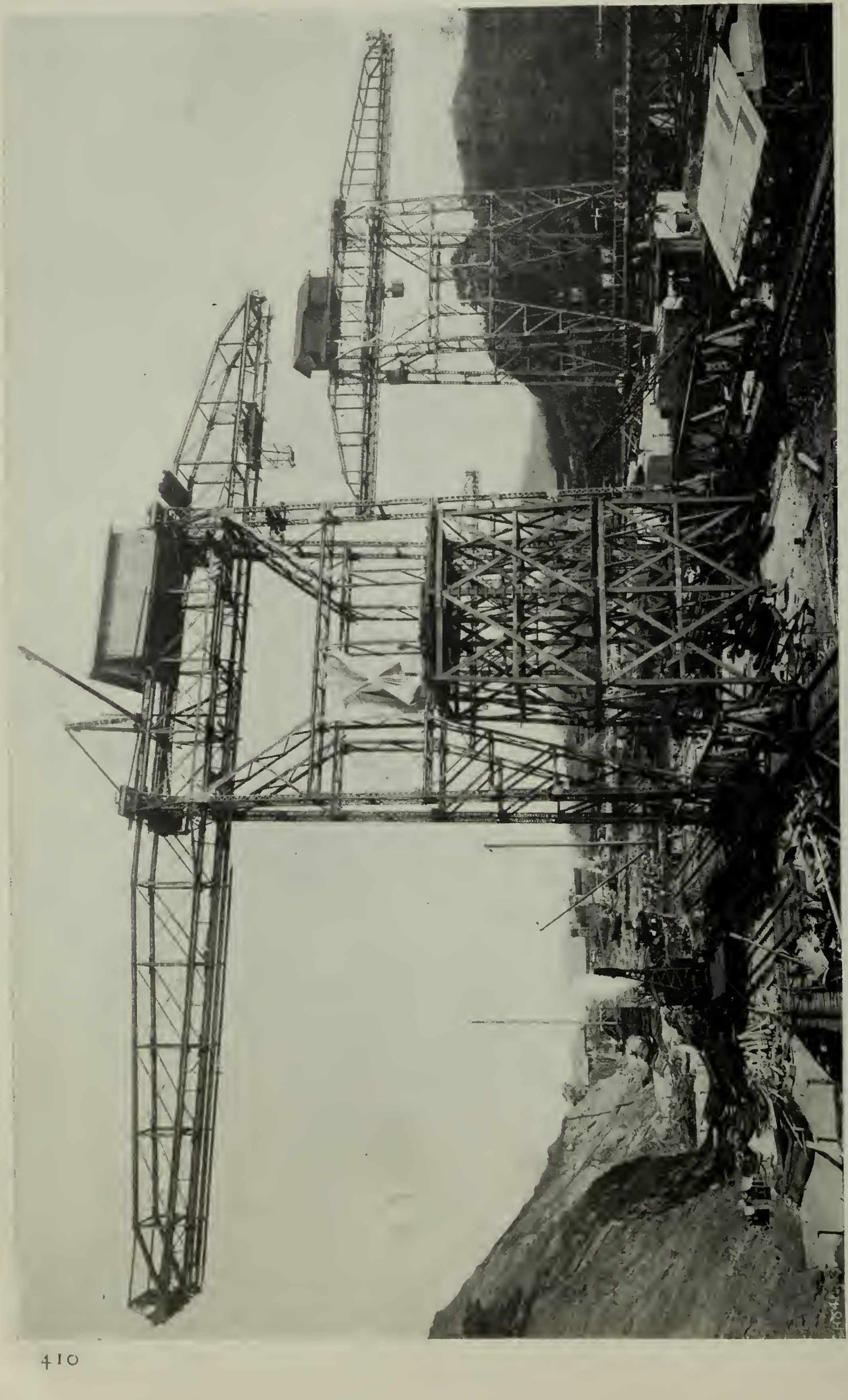


Fig. 13. Chamber Cranes at Pedro Miguel Locks.

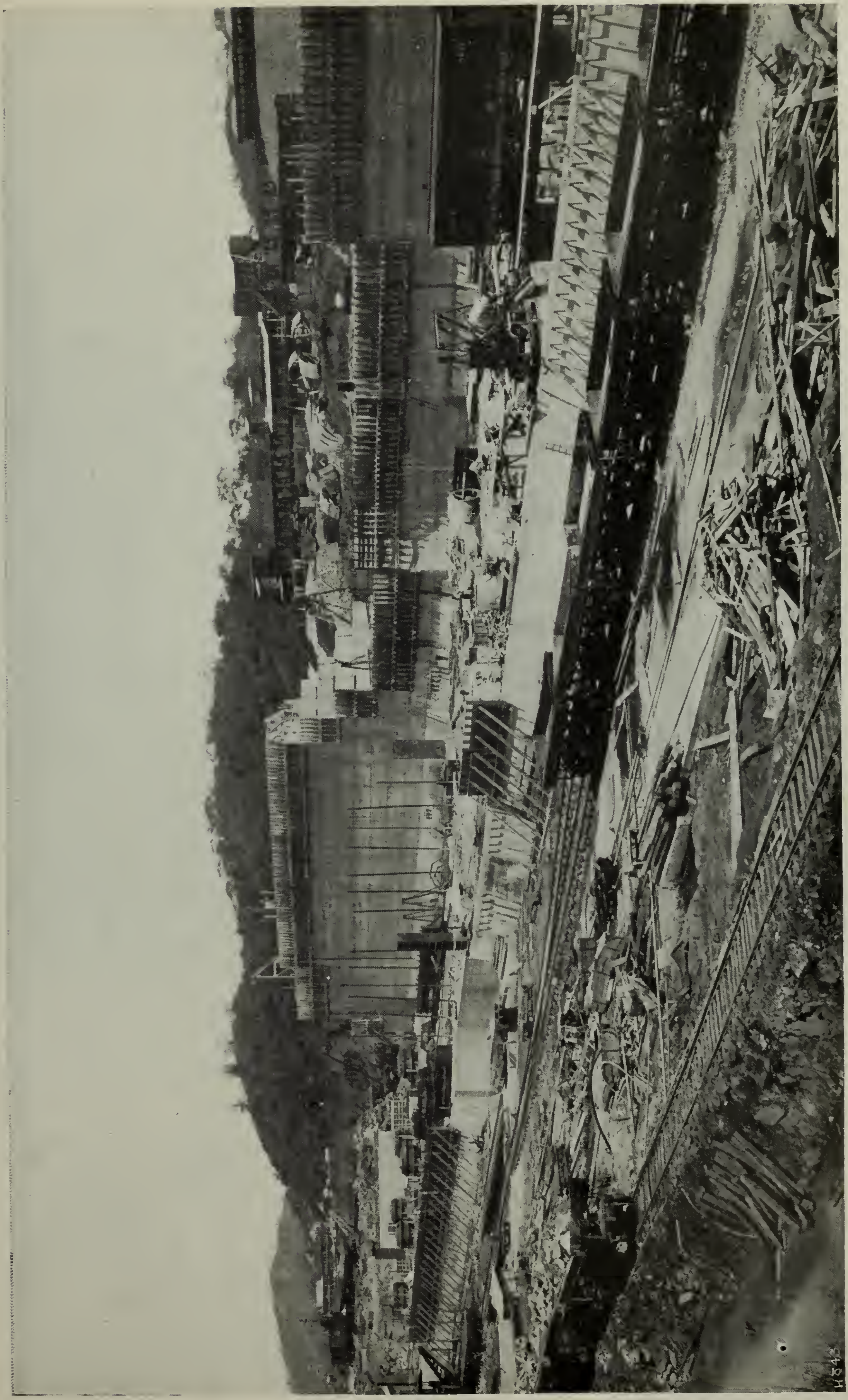


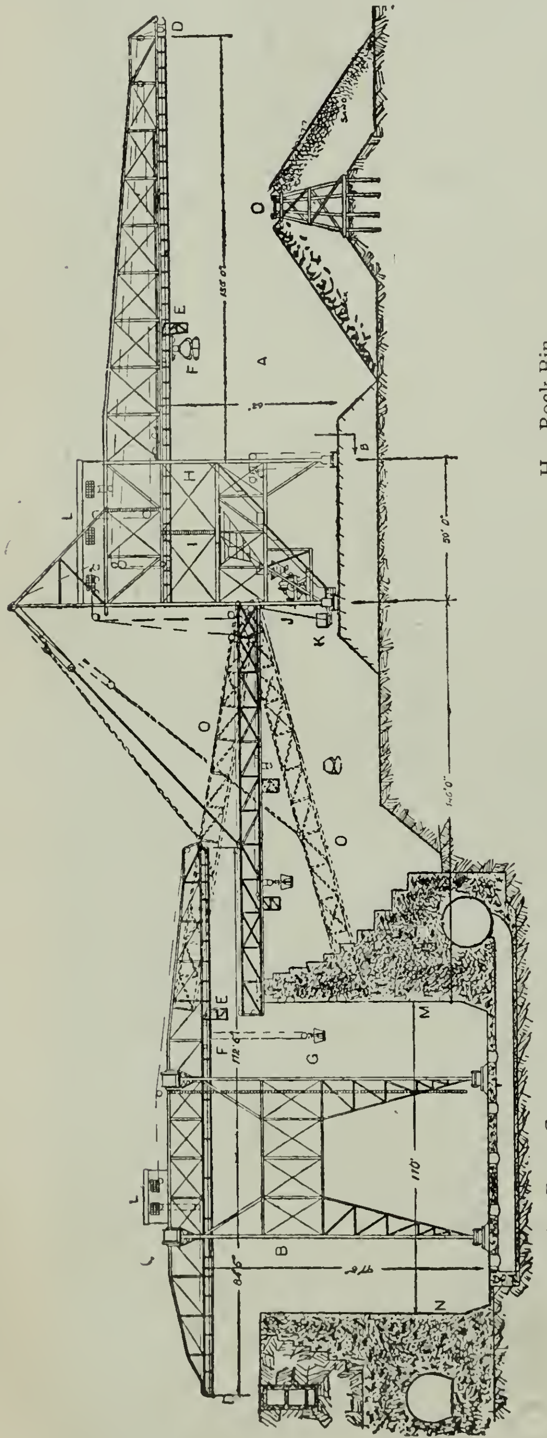
Fig. 14. Miraflores Upper Locks.

on the cantilever supplies sand and rock, while the boom carries a trolley equipped with a 64 cu. ft. concrete bucket, into which the concrete is dumped direct from the mixers.

Sand and Rock Supplies.—All stone required for the concrete work of the Pacific division is quarried from and crushed at Ancon Hill, situated between the city of Panama and Balboa. The sand needed is obtained from Point Chamé, 20 miles up the coast from Panama, and, after being towed to Balboa, is transported from barges to cars by rapid unloaders, for rail carriage to the locks.

Reinforced Concrete Barges.—To obtain the required depth in a section of the Canal extending about 1½ miles south of Miraflores locks there needs to be excavated—by dredging and subaqueous methods—an estimated quantity of 1,503,260 cu. yd. of rock. Before, however, this work can be commenced, it is necessary to deal with an overlying mass of alluvial material, averaging 38 ft. in depth, and of the aggregate quantity of 8,158,133 cu. yd. To handle this loam hydraulic excavation has been selected as the cheapest and most expeditious method, especially as the material removed may be used to redeem about 450 acres of adjacent swamp.

Two principal operations are involved—namely, disintegrating the material and washing it to sumps by means of water jets driven through monitors at high pressure, and lifting and conveying it through flumes by means of dredging pumps. As the latter will have to be moved from time to time, floating supports of light draught are required, and to serve this purpose reinforced concrete barges were selected as most economical, seeing that they could be built on the spot, at a cost very much less than steel, and only slightly in excess of wooden barges, while the expense of maintenance is practically *nil.*



A. Berm Crane
B. Chamber Crane
C. Storage Trestle for Sand and Rock
G. 2 cu. yd. Bucket for Placing Concrete

H. Rock Bin
I. Sand Bin
J. 2 cu. yd. Concrete Mixer
M. Side Wall of Lock

Fig. 15. Arrangement of Cranes at Miraflores Locks.

The experiment is doubly interesting by reason of the fact that this is the first recorded attempt to adapt concrete-built barges to Transatlantic engineering, though such barges—flat-bottomed and with a rake at both ends—are extensively used on several American rivers.

Method of Construction of Barges.—Each of the three barges built at Miraflores (*Figs.* 16 to 19) is 64 ft. long, 24 ft. wide, and 5 ft. 8 in. in depth, the hulls being divided into three compartments by longitudinal bulkheads spaced 8 ft. on centres. The gunwales, bulkheads, and bottom are tied together and stiffened by lateral frames at intervals of 10 ft. The deck has a sheer of 4 in. and is crowned 1 in. The gunwales and bottom are reinforced—in the case of No. 1 barge—with ½-in. mesh, No. 12 wire cloth, attached to ½-in. square corrugated bars, spaced 9 in. longitudinally, and 12 in. crosswise. The frames are knee-braced and reinforced, as shown in *Figs.* 18 and 19; while the decks consist of concrete slabs, 3½ in. thick, having spans of 10 ft. in length and 8 ft. in width, reinforced with ½-in. rods. both longitudinally and transversely.

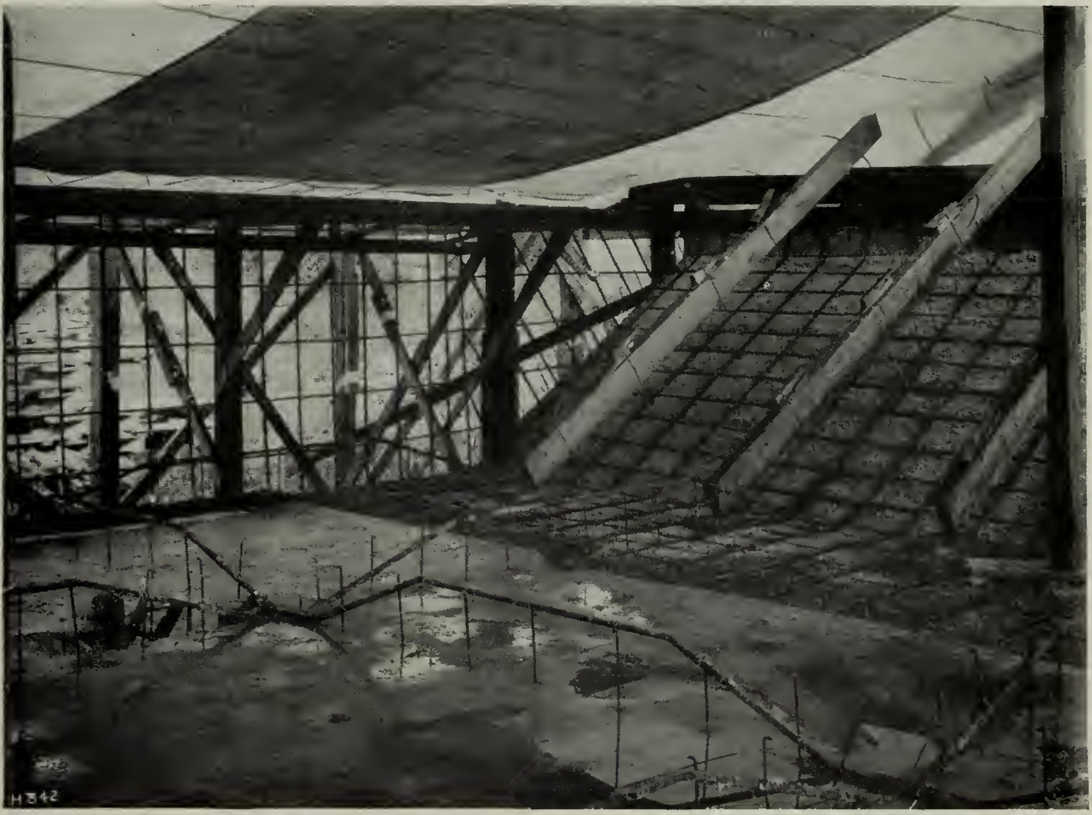


Fig. 16. Interior of Reinforced Concrete Barge in Course of Construction.

In construction, the wire cloth reinforcement of the bottom, sides and rakes was placed on cribbing of sufficient height, and so arranged as to permit working underneath the bottom. The rods, previously bent to the proper shape, were then securely wired to the mesh. This formed the skeleton of the barge, and the whole was plastered with hydraulic cement mortar to which had been added 25 per cent. of lime. The plaster was laid on the outside of the wire mesh in two coats aggregating ½ in. in thickness, and the inside was then plastered thick enough to cover the reinforcing rods, the result being a slab about 2½ in. thick. The plaster was rubbed down to a hard, smooth surface, especially on the outside.

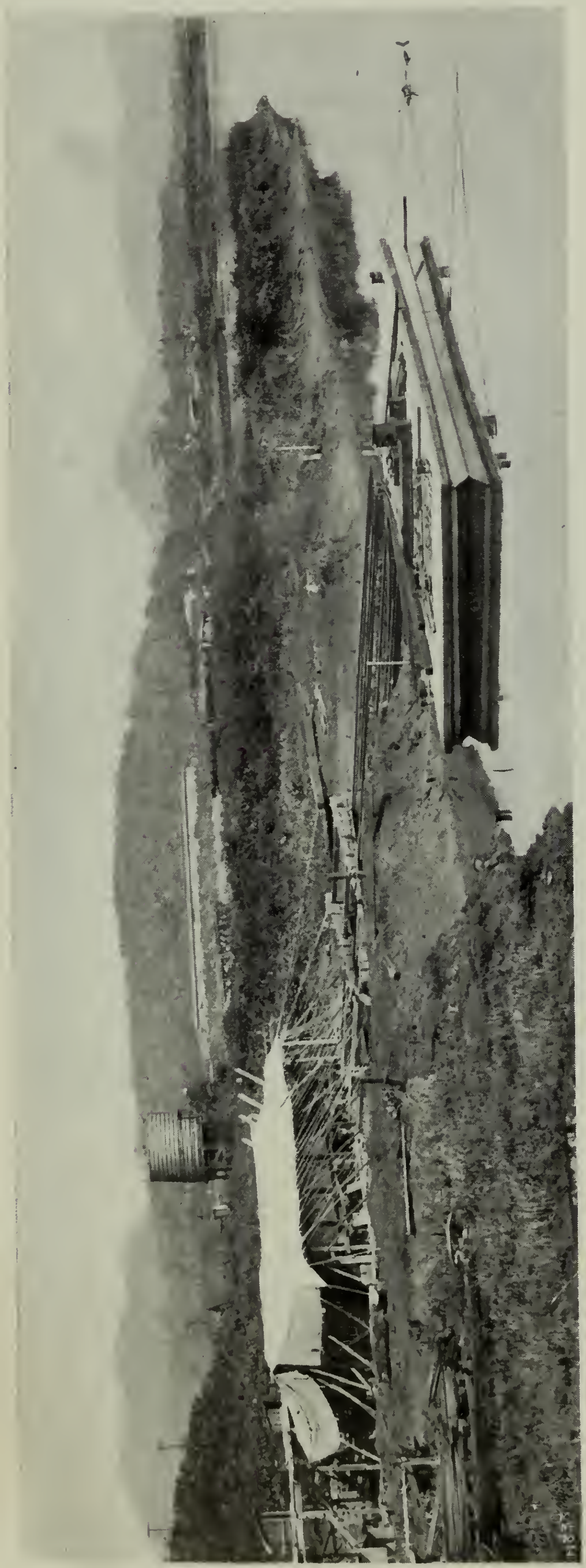


Fig. 17. View showing One Reinforced Concrete Barge Launched and One During Construction.

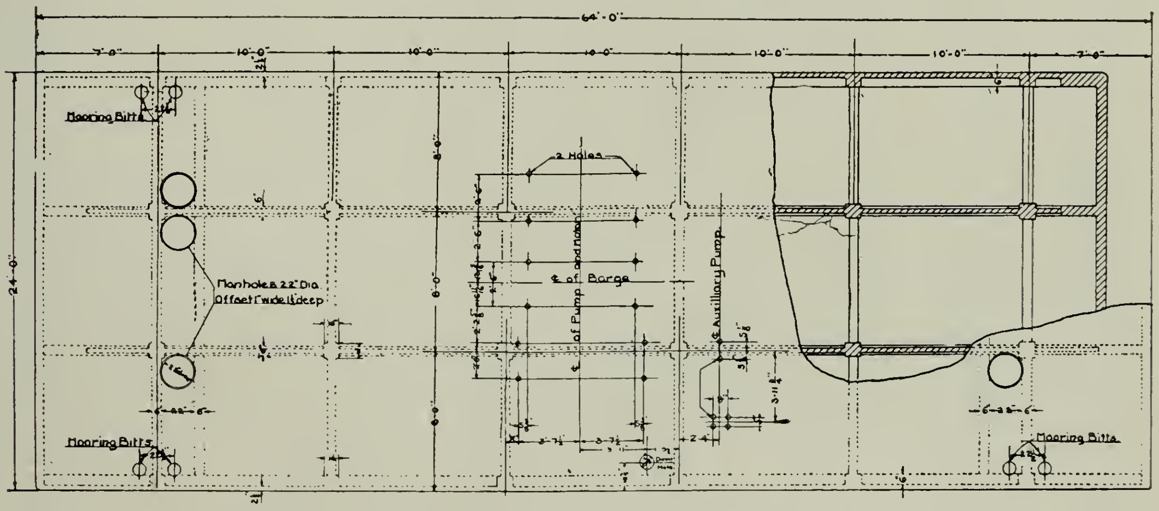
Upon the completion of the shell, the reinforcement and forms were placed for the bulkheads and cross frames, the reinforcement being securely attached to the shell by wires and ¼-in. hooked rods previously inserted in the shell for this purpose. The frames and bulkheads were then filled with concrete to the bottom of the deck slab, and, finally the latter was placed in the usual manner and given a trowel finish. Wooden forms were used throughout, the interior form work being built in collapsible sections, for ready removal as the operations advanced.

Draught and Weight.—The dredging plant, motor, and equipment, weighing about 60,000 lb., is placed near the middle of the vessel, and adds 3 in. to the 3 ft. draught of No. 1 barge. This was launched on April 20th, 1910, twelve days after completion, and a lesser period after the appearance of five or six cracks on the bottom and one in the gunwale. Several of these seemed to extend through the slab, and leaked slightly when the barge, for purpose of testing, was partly filled with water. The cracks were cut out and plastered, and no leaks have since developed.

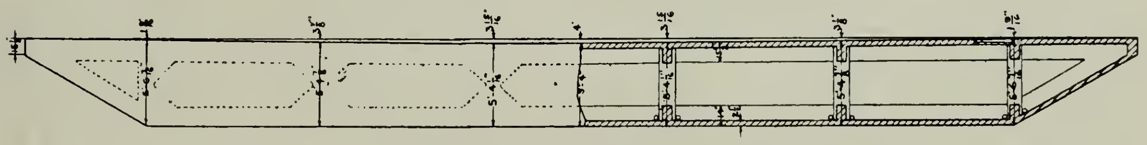
The weight of the concrete, including the plaster, was assumed at 150 lb.

per cu. ft., and the actual weight of the steel taken, for computing the theoretical displacement. The draught of the first barge, however, is greater than that computed by slightly over 3 in. The reason, so far as the writer is at present informed, has not been ascertained ; but, as regards the barges built later, careful records have been kept of the dimensions and materials used in order to secure more accurate data for computing the displacement. In the second and third barges, the amount of reinforcing material is somewhat less than in the first—¼-in. mesh No. 12 wire cloth being used instead of ½ in., with consequent reduction of aggregate weight and draught of water.

It is believed that for purely commercial or transportation purposes the designs of the barges here described might be so modified as to lighten them materially. A fourth concrete barge, to be used for dredging and general purposes about the harbour, is at present under construction at the Balboa shipyard ; and this will be followed by the building of reinforced concrete dump scows larger than any yet designed, which, it is thought, will be found the most economical type for service not only during the remaining stages of Canal construction, but also for maintenance after the opening of the highway.



PLAN



SIDE AND SECTIONAL ELEVATION

Fig. 18. Reinforced Concrete Barge.

Setting Temperatures.—Interesting data concerning the setting temperature of concrete in large masses should attend the tests inaugurated at Gatun locks. At points in the centre and side walls, indicated in *Fig.* 20, thermometers were embedded as the concrete reached the successive heights, and after completion of all the connections and calibration by comparison with twelve mercury thermometers in an oil bath. The thermometers are simply fine wires of high resistance, wound into spirals, in water-tight glass tubes, protected by steel casing, and are connected by a lead-covered copper cable with a galvanometer

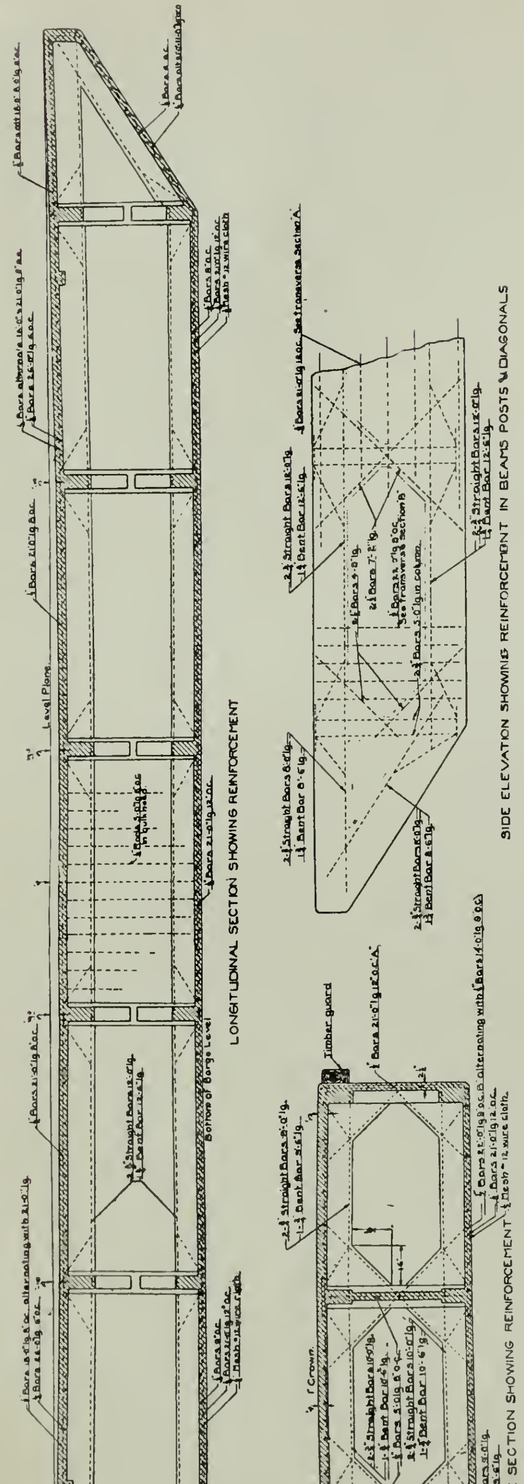

LONGITUDINAL SECTION SHOWING REINFORCEMENT
SIDE ELEVATION SHOWING REINFORCEMENT IN BEAMS POSTS & DIAGONALS
TRANSVERSE SECTION SHOWING REINFORCEMENT
Level Plane
Bottom of Barge Level
Timber guard
Crown

FIG. 19. SECTIONS AND SIDE ELEVATION OF REINFORCED CONCRETE BARGE.

placed in the office of the resident engineer. This galvanometer is graduated in centigrade degrees, and arranged for seven different circuits or thermometers. Each of the latter is controlled by means of a push switch, so arranged that when one of the switches is closed all the others are opened ; thus the possibility is avoided of two or more thermometers being thrown on to the recording instrument at the same time. A standard resistance is connected to the galvanometer by a testing switch ; and a resistance to adjust the galvanometer to a full-scale deflection and an adjustment for setting the needle at zero are also provided. The electric current for the instrument is supplied from two storage cells, the electro-motive power of which is practically two volts each.

The principle of the thermometer depends on the rise of resistance due to rise of temperature. As the temperature of each element rises, due to the setting of the concrete, its resistance rises, and the galvanometer is graduated in degrees corresponding to the temperature of the thermometer. The frequency with which the temperature is taken is determined by the rate of change from time to time. The results are plotted with time as the abscissa and temperature as the ordinate, and in this manner a complete graphical record of the hardening and cooling of the concrete will be obtained. In the curves comprising *Fig.* 21 are shown the variations of temperature at several points of the lock wall monoliths during the early stages of setting.

Effect of Salt Water.—Experiments are also being made to determine the effect of salt water on the concrete of the lower sea-level locks and the

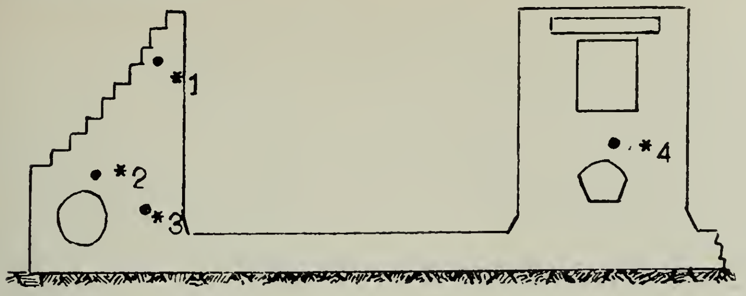


Fig. 20. Position of Thermometers in Concrete Walls, Gatun Lock.

guide walls leading into them. To this end six slabs of concrete similar to that used in the lock masonry, and about a yard square, have been prepared and placed in the water simultaneously at spots adjacent to the sites of the lower guide walls at Gatun and Miraflores. Two of the blocks have been left untreated ; two others have been treated with sodium silicate in the form of soluble glass in solutions of different strength ; while the remainder have been subjected to Sylvester's process with alum and soap—$\frac{3}{4}$ lb. of soap to 1 gallon of water being applied hot for the first wash, followed, 24 hours later, by a solution of alum, 2 oz. to the gallon, applied cold. One of each pair of slabs has been given a double coat, and the other two double coats, of the respective washes.

The blocks will remain immersed until the guide walls are erected, and it becomes necessary to decide whether or not these should be treated to resist salt water. At Miraflores about 1,400,000 sq. ft. of surface will be exposed to the action of salt water, and at Gatun about 1,270,000 sq. ft.

So far as present knowledge on the subject goes, and always assuming that a good close finish is made, so as to prevent water getting into the pores of the concrete, there seems little reason for anticipating difficulty. As a matter of fact, there are now lying on the beach at Colon blocks of concrete made by the French about thirty years ago for protecting the sea-front of Cristobal, which, notwithstanding their long exposure to the action of salt water, show but small evidences of deterioration. It must also be remembered that, owing to the admixture of fresh water from the locks, the water below the Gatun and Miraflores flights will usually tend to be brackish.

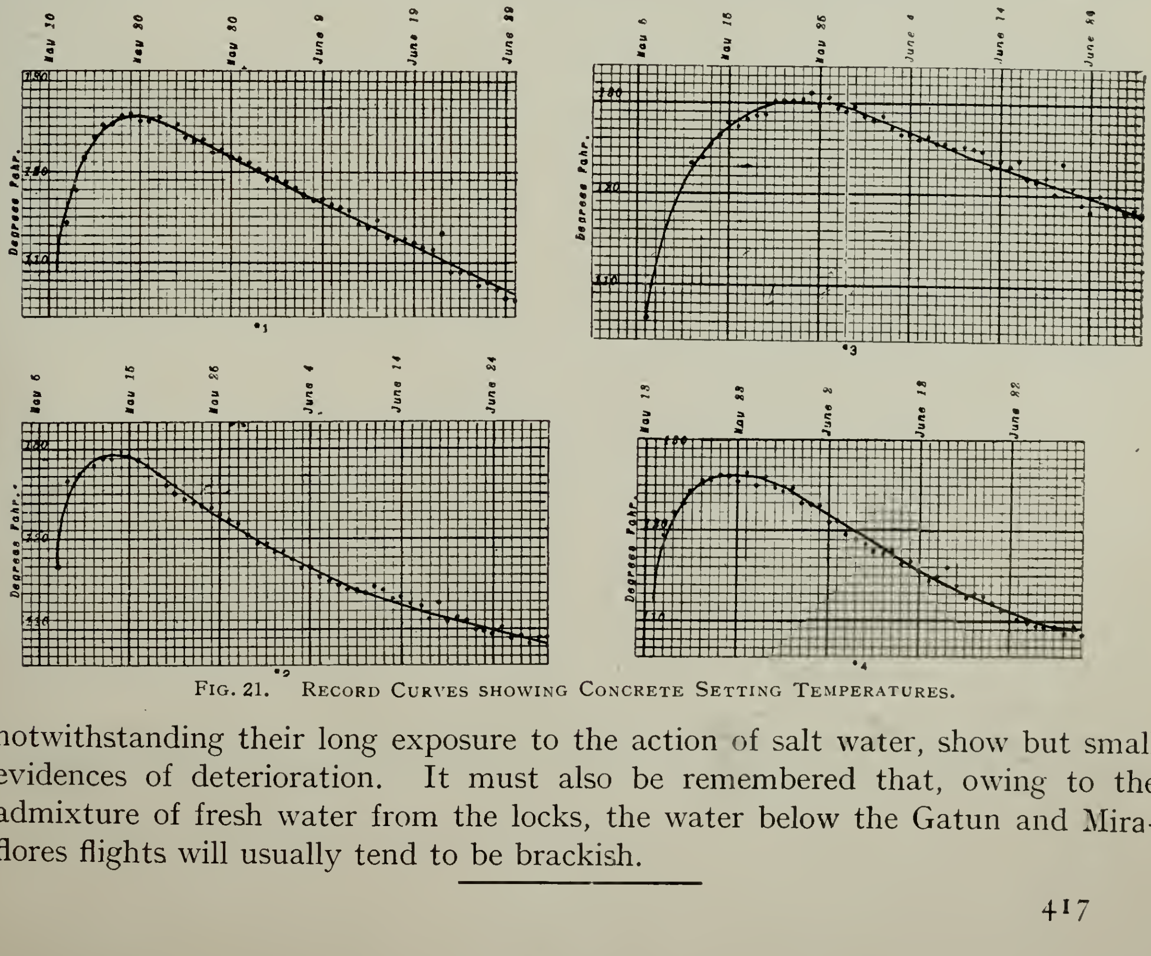
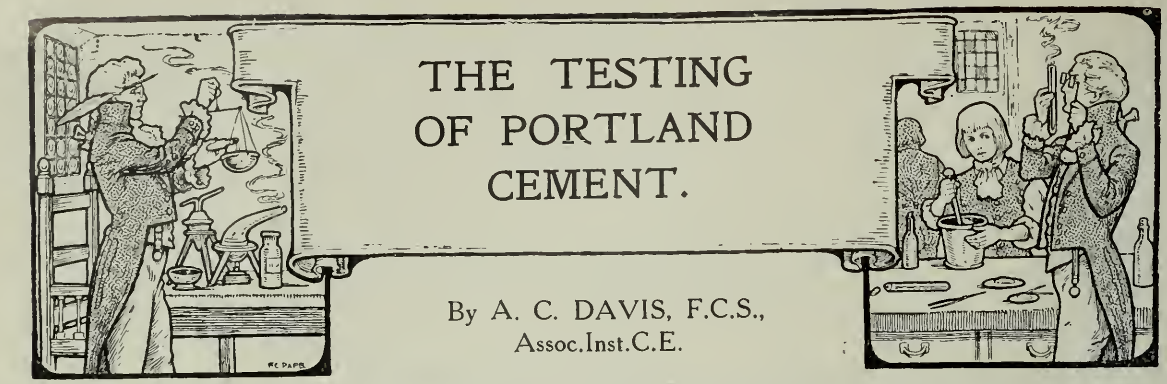


Fig. 21. Record Curves showing Concrete Setting Temperatures.



THE TESTING OF PORTLAND CEMENT.

By A. C. DAVIS, F.C.S.,
Assoc.Inst.C.E.

It affords us considerable pleasure to note that the Cambridge University has arranged some lectures dealing with Portland cement, and by the courtesy of the lecturer, Mr. A. C. Davis, we are presenting some of his principal discourses.—ED.

In regard to the testing of Portland cement, I think I am right in saying that of all the materials of construction subject to a system of testing, Portland cement is probably the most dependent on the judgment and skill of the tester, and with all the well-equipped laboratories and apparatus it is still impossible to remove the most important factor of personal equation.

In order to obtain the knowledge usually sought for as to the qualities of cements to be used, it is first necessary that the samples which are taken for investigation should represent the whole quantity of the bulk. Therefore, as soon as the cement has been bulked, either at the manufacturer's works, or on the works in connection with which the material is to be used, samples are generally taken from each parcel of cement, and are so distributed as to give as far as possible a fair average sample of the whole parcel. When all these samples are mixed together the parcel for testing can be taken therefrom, and the material is then generally tested in accordance with the terms of the British Standard Specification.

Now the requirements of this specification arrange that the cement shall be tested for :

1. Fineness of grinding ;
2. Specific gravity ;
3. Chemical composition ;
4. Tensile strength (neat cement) ;
5. Tensile strength (cement and sand) ;
6. Setting time ; and
7. Soundness.

Personally I would revise the order in which these tests stand in examining a sample of cement, and I think it would be preferable to take each test as it would naturally occur in practice—namely :

TESTS FOR FINENESS.

The first inquiry the cement user makes as to the quality of the material under notice takes the form of a test for fineness ; thus in passing through the manufacturer's stores, or when the first bag is opened on the contractor's works, the cement is mechanically and half-unconsciously passed through the fingers in order to ascertain the fineness. The coarse particles in a cement can thus be readily perceived, and the practiced tester is, in this way, able to gauge approximately the residue present in the sample.

For the past three or four years there has been a growing desire on the part of engineers for a much finer cement, and it may be said that the principle of fine grinding is now in the ascendancy—an improvement in the manufacture greatly in favour of the consumer both as regards economy in use and reliability in result. Too much attention cannot be paid to fineness of grinding, for the finer the cement the more intimately can it be incorporated with the aggregate used for the concrete, and therefore the stronger will be the work.

The test for fineness, therefore, derives importance from the fact that, other qualities being equal, fine cement has a much greater sand or aggregate-carrying capacity than coarse cement has ; that is, it will show an increased strength with the same charge of sand, or equal strength with a greater charge.

Now, Portland cement, as delivered by the manufacturer, consists of a mixture of coarse and fine particles, respectively known as " residue " and " flour." The residue is the coarsely ground clinker left on the fine sieves which are used for testing. and the value of the flour in a cement is, that the very fine particles are believed to contain principally, if not wholly, the cementitious property of the material. I would not go so far as some authorities by stating that residue is practically inert, or even possibly so much adulteration. It is found to be a cement that is generally the hardest and best burned materials that have not been reduced in the process of grinding, and therefore only sufficiently fine for the water added in use to attack the surface of the particles, the interior of which remains inactive.

It is very commonly stated, for instance, that the larger particles of cement clinker in the manufactured product are of no greater value than grains of sand. This opinion is deemed fallacious in principle, for measurements of size are purely relative and the smallest particles of cement flour are large compared with atoms or the hypothetical electrons of which atoms are now said to be composed. Some recent experiments upon this point prove that the coarser particles of cement may possess considerable tensile resistance, and therefore they constitute a valuable constituent of that material. They also show, however, that such particles may be quite different from the finer particles in respect of soundness, and suggest the possibility that the coarser particles sometimes cause general deterioration affecting the whole body of the cement. Thus they may be either valuable or deleterious, and certainly making always a further investigation of each individual circumstance of test highly valuable. If this residue were reduced to flour, however, it will generally be found to be a good quality cement showing high tensile strength. Therefore a sample of cement as delivered to the consumer, if divided into residue and flour, will show that on a sieve having 180 by 180 meshes per sq. in. the residue will be about 18 per cent. and the fine grit and flour about 82 per cent.

In extracting the flour by means of light air pressure we see that the average cement contains from 50 to 60 per cent. of flour, the balance being a very fine grit that has passed through the meshes of the sieve.

Portland cement, therefore, when delivered on to the work is thus first tested for fineness of grinding, and only a few years ago the usual fineness called for in cement was about 10 per cent. residue on a 50 by 50 mesh sieve, or a sieve having 2,500 holes to the sq. in., but to-day the average fineness of good quality cements is more likely to be as follows :

No residue	50 by 50 mesh sieve
Trace	76 by 76 ,, ,,
Five per cent.	100 by 100 ,, ,,
Fourteen per cent.	180 by 180 ,, ,,

In carrying out the test for fineness it is generally arranged that a quantity of 100 grams of cement, approximately about 4 ozs., shall be continually sifted for a period of 15 minutes, and the results should be as I have now described. The sieve generally used for this test is as I show here, and the British Standard Specification stipulates that the amount of residue on the 180 by 180 mesh sieve shall not exceed 18 per cent.

A cement that passes this test can be considered a thoroughly first-class quality product in every respect, provided of course the further tests of the cement are satisfactory.

TESTS OF THE SETTING TIME.

The *next* test that would be carried out in gauging the quality of cement is probably that of the setting times.

When Portland cement is mixed with water a plastic paste is formed which ultimately hardens into a stonelike substance, and according to the activity shown in this transition from a paste to a thoroughly hard mass, so is the material found to be of a quick or slow-setting nature.

The setting of cement, scientifically explained, means that on the addition of water to a cement calcium aluminate is first attacked and broken down to a simpler aluminate and hydrated lime. These materials dissolve in the water, and when a state of supersaturation is reached are deposited in a crystalline form, thus causing a stiffening of the mass, known as the initial set.

This process of crystallisation continuing produces increasing hardness, which is further assisted by a similar but much slower decomposition of the calcium silicate into a simple compound plus hydrated lime. The growth in the strength of cement is due partly to the gradual decomposition of the calcium silicate, as just explained, and partly to the absorption of CO_2 by the liberated lime to form $CaCO_3$ (which compound in the crystalline form, that is, limestone, can acquire considerable tenacity). The coarser particles of cement are not completely penetrated by water for some weeks, if not months, and as long as the penetrating process continues the breaking up and crystallisation of each particle adds to the strength of the whole.

Most cements when freshly made are extremely quick setting, that is, as soon as water is added to the ground material the cement begins to harden at once if it is not treated by the manufacturer during the clinker grinding process. Cement as ground from the kiln may vary in its setting time from a few minutes to some hours, and such a material to a consumer would prove irksome and inefficient, but by the introduction of a material called gypsum ($CaSO_4$), which is mixed in very small proportions with the material while passing through the grinding machinery, a cement is obtained which can be relied upon as being of a slow and generally uniform set.

To regulate the setting of cement, then, it has been found necessary in its manufacture to add a small percentage of this product gypsum to the clinker whilst the same is being ground, and gypsum has been proved to be not only perfectly harmless but really beneficial to the product.

It is a mineral found in a great variety of forms and is chiefly mined in Nottinghamshire, where it exists as a nearly pure calcium sulphate.

The addition of gypsum in the proportion of 1 to 1½ per cent. generally does all that is desirable and necessary in slowing down the setting time of an inordinately quick-setting cement.

To explain the influence of gypsum upon the setting of cement, it must be remembered that the process of setting is one of solution and subsequent deposition of crystals from this solution, which intertwine round the undissolved particles and bind the whole mass together; but cement is less readily soluble in a solution of $CaSO_4$ than it is in pure water, hence it will be seen that when $CaSO_4$ is present either in the fuel ash or as added gypsum, this material dissolves first in the water used for gauging, and in the solution thus formed the cement takes longer to dissolve and deposit its crystals, and in this manner the setting is retarded in proportion to the strength of the $CaSO_4$ solution, that is, in proportion to the amount of the added material.

Sometimes in the regulation of the setting time of cement the manufacturer has also recourse to a steam hydrating of the clinker in the mills during the clinker grinding operation, but this gives unreliable results. Or again, an extensive " weathering " or atmospheric slaking of the clinker before grinding is required, and some manufacturers find it desirable to water the hot clinker when leaving the kilns and previous to grinding. The latter arrangements are more particularly adopted where the addition of gypsum for some chemical reason is found to be practically useless, but even these methods cannot always be relied upon to give satisfactory results.

Until the advent of the rotary kiln all cements were so contaminated with the ash of the fuel used for calcination (which ash contained a high proportion of SO_3), that the material leaving the kilns required little or no addition of gypsum in order to produce a slow- or medium-setting cement. Rotary kiln cement, however, contains practically no fuel ash, and is consequently lacking in SO_4 and is instantaneous in setting, unless the necessary sulphur is introduced in the form of additions of gypsum during the process of grinding.

It is of importance that the cement user should be aware of the setting properties of the cement to be employed in constructional work, for unexpected results are apt to ensue from the omission of this test. It often happens that when a quick-setting material is inadvertently delivered on to the contractor's works, and is brought into use, the setting has commenced even before the wet mixing of the aggregate and cement is completed, with the result that this setting action, being unnoticed, is interfered with, and the material will not again set for some days, or, at least, until the moisture has thoroughly dried out of the mixture, and even then its cohesive value is often so greatly reduced as to render the cement practically valueless. This is a common occurrence in the use of cement, and may easily be avoided by a systematic testing of activity. Care, then, should first be taken to ascertain the setting time of the cement, and next, that no greater bulk of mortar is mixed than can be used before the setting commences.

Under no circumstances must a cement which has once been allowed to set be re-tempered or re-mixed for use, since from what has been said it will be seen that the material is thereby rendered worthless.

Cement manufacturers, then, have it in their power to make either a quick- or slow-setting cement, and, unless otherwise instructed, supply the slow-setting quality, which takes thirty minutes and upwards to harden the surface of the test pat. A quick-setting cement commences to harden in a few minutes, and although perhaps equally strong in its tensile resistance and constructional value, yet a cement of this nature must be used with care. It is employed under water, in plaster work, and when working in cold weather. In all other cases it is most advantageous to use a slow-setting cement.

This is indeed indispensable when dealing with careless workmen not under supervision, who always prepare their concrete many hours ahead, and even sometimes drown it with excessive quantities of water.

Now the two setting-time tests at present in use are one for the commencement of the setting, called the " initial " set, and the other for the end, or " final " set, the time when a weighted needle makes no impression on the test pat.

The Initial Set.—The initial set of a cement is generally gauged from a small pat made with a minimum amount of water. The commencement of set is seen to occur when crystallisation of the cement starts by the drying of the pat and upon its assuming a certain amount of solidity. The pat can be prepared by taking 100 grammes of cement, and in well mixing the same on a non-porous slab with 25 per cent. of water of a temperature of 58°–64° Fahrenheit. The time employed in mixing this cement should not exceed 40 seconds, and then the plastic mixture should be placed upon a glass or iron plate, and shaken down to a thickness of ½ in. in the centre and a diameter of 4 in.

The pat is then placed aside to allow the cement to set, and the initial setting time is plainly shown, and is indicated by a certain drying appearance, and a slight resistance is observed to the point of a pencil.

The final set takes place when the cement will not take an impression by a weighted needle.

Unless a specially slow-setting cement is required of which the minimum time of setting has been specified, the manufacturer generally supplies a cement of one of three distinct gradations of time of setting, designated as quick, medium, and slow. *Quick*-setting cement implies that the initial setting time should be not less than two minutes and the final setting time not less than 10 minutes nor more than 30 minutes. *Medium*-setting cement should have an initial setting time of not less than 10 minutes, and the final setting time should be not less than half an hour or more than 2 hours. *Slow*-setting cement should have an initial setting time of not less than 20 minutes, and the final setting time should be not less than 2 hours or more than 7 hours.

The Vicat Needle Process.—In carrying out the test of the setting time of cement with the Vicat needle apparatus, such as we have here, the mode and conditions of gauging the cement are as follows :

The quantity of water used in mixing with the cement to be tested should be appropriate to the quality of the cement, different brands of cement requiring different percentages of water, and the quantity of water should be so proportioned that when the cement is gauged it forms a smooth, easily worked paste, which leaves the trowel cleanly, in a compact mass. Clean, fresh water and appliances are to be used in gauging, and the temperature of the water and that of the testing room during the time the setting operations are performed should be from 58° to 64° Fahrenheit. The gauging should be completed before signs of setting occur, and after preparing the cement in this way the mortar is filled into the mould of the Vicat needle apparatus.

This testing apparatus, as will be seen, consists of a frame bearing a movable rod with a cap at one end and a needle 1 mm. square at the other. The cap, rod, and needle together must weigh 300 grammes (10·58 oz.). The rod carries an indicator which moves over a scale (graduated in centimetres) attached to the frame. The cement paste is held in the conical split ring 8 cm. in diameter at the base and 4 cm. high, and this ring rests upon a glass plate. The paste confined in the ring resting on the plate is placed under the rod bearing the needle, which is then carefully brought into contact with the surface of the cement and quickly released. The initial setting time is said to have commenced when the needle no longer pierces through the pat. When sufficient time has elapsed to allow of the mould being lifted without disturbing the cement, the mould is turned over to enable the needle to be applied to the under-surface of the cement. The cement is considered as finally set when the needle, having a flat end of 1 mm. square, fails to make an impression when its point is *applied gently* to the surface.

TESTS FOR SOUNDNESS.

Then probably the third test carried out in the examination of cement will be the test for soundness, which includes testing for contraction and expansion.

The soundness tests are those which connect themselves definitely with some serious defect to which cements are subject, and are of paramount importance. The tests can be made with the most simple apparatus—if, indeed, *any* apparatus is required—is easy of manipulation, and its results are obtained immediately.

Numberless methods are in vogue for ascertaining the soundness of cements, and the inquiries more generally classified under this heading are those which have reference to constancy of volume, and to this end an accelerated or boiling test is employed in order to ascertain the exemption of cement from undue expansion.

The accelerated tests most generally used are those of putting the pat or block of cement in steam and in hot and boiling water, and examining the results after some hours. If the cement is sound the boiled pats will be quite perfect in shape; but if unsound and badly manufactured the cement will crack, and in isolated cases will sometimes boil away to mud.

As to these tests for expansion, it cannot be stated that results which may be obtained by an accelerated test are identical with those which may be experienced in actual construction work; but there is no doubt that if the cement is in the slightest degree unsound the hot test will at once detect and emphasise the weakness.

The expansion of cements under the accelerated test is generally caused by what is known as "free" or uncombined lime, and this is introduced into the product either by careless or unscientific mixing or burning of the raw materials used in the manufacture, or by the incorporation of underburnt clinker from the kilns.

If a cement is poorly manufactured the aeration or atmospheric slaking, which is often carried out upon construction works to-day, will eliminate to some extent what free lime may be present; but a properly-manufactured cement will withstand the hot or boiling tests as soon as the material is taken from the grinding mills.

In the early days of cement manufacture most of the trouble of cement users was due to the expansion of the material through overliming and other faults in the manufacture. This caused a swelling and ultimate disintegration after the work was in place.

To-day, however, cements which stand the accelerated tests by steam or boiling water should be used in preference to others; and, moreover, such tests should be constantly applied on the work of concrete construction, for although the hot tests sometimes reject suitable material, they will always reject material unsound by reason of the existence of active expansive elements.

To carry out a rough-and-ready soundness test, therefore, it is only necessary to take a pat of set cement and immerse the same in a receptacle of cold water. The water should then be brought slowly to a point of boiling, and the pat of cement kept under water for five or six hours. Under this test no warping or cracking of the cement pat at the edges should take place; and if the pat is perfectly sound after being under observation for the period mentioned, it may be taken that the cement may be used in concrete work with every advantage.

This accelerated test is more efficient than another old-time device for the test of over-liming or expansive cements. This other arrangement was to mix a sample of the material with water to about the consistency of cream, the mixture being then poured into a small glass test-tube, which is shaken until full to overflowing, and then placed aside in a cool place. If the cement is over-limed, or even if the grinding and amalgamation of the raw materials have not been properly carried out by the manufacturer, the cement will expand and split the glass, sooner or later, according to the degree of the imperfection. If, on the other hand, the cement is underlimed (or over-clayed), it will contract and become loose in the receptacle.

In this test, however, care should be taken to keep the tubes in a cool place or in an even temperature, for if placed in a warm atmosphere or near a fire cracking will result through the different rates of natural expansion with glass and cement, even if the cement be perfectly sound. This cracking will, moreover, occur on account of the normal expansive and contractive tendencies of cement caused by heat and cold.

I could enumerate many other tests for showing the soundness of cement, but since my time is short I will now only further refer to the test of expansion in Portland cements as outlined by the British standard specification.

Le Chatelier Test.—This is called the "Le Chatelier" test, and it consists of filling a small split cylinder of spring brass with cement, thus forming a mould 30 mm. internal diameter and 30 mm. high. On either side of the split in the metal mould are attached two indicators with pointed ends, and the distance from these ends to the centre of the cylinder is 165 mm.

In conducting this test for showing the soundness of cement the mould is first put upon a small piece of glass and filled with cement gauged in the usual way, care being taken to keep the edges of the mould gently together while this operation is being performed. The mould is then covered with another glass plate, a small weight is to be immediately placed on this, and the mould is then placed in water at a temperature of 58° to 64° Fahrenheit and left there for twenty-four hours.

The distance separating the indicator points at the end of this period is then to be measured, and the mould placed in cold water, which is to be brought to boiling point in about thirty minutes and kept boiling for six hours. After cooling, the distance between the points is again to be measured, the difference between the two measurements representing the expansion of the cement, which must not exceed the limits laid down by the British standard specification.

These limits are that the cement when tested by the Le Chatelier method shall not in any case have a greater expansion than 10 mm. after twenty-four hours' aeration of the cement, and 5 mm. after seven days' aeration. Since, however, the manufacturer generally keeps in stock a considerable quantity of cement, so as to supply engineers with a perfectly cool product fit for immediate use, the cement should test not more than 5 mm. expansion.

Contraction Test.—Now included in the soundness tests we have also a test for contraction. Contraction cracks in the test pat are often met with, but are rarely a sign of bad quality. They are perhaps more generally found to be due to faulty testing rather than to a deterrent quality in the nature of the cement.

However, there is a test in existence which clearly shows the contraction of cements, and although this is not a test adopted by the British standard specification, it is a test often carried out by engineers. The apparatus used in this method of testing the contraction of cements is a *tapered* mould of 3⅝ in. diameter (inside measurement) and 1½ in. high. This mould is filled with neat cement of a plastic consistency, which is left to dry off and set hard. If there is any contraction the cement block will be loose and will leave the mould; and, if not, the block of cement will remain tight in the mould.

TESTS FOR ASCERTAINING THE TENSILE STRENGTH.

Then the fourth test of importance is that of ascertaining the tensile strength of both the neat cement and cement and sand at varying periods. By "neat" tests I mean those in which pure Portland cement is used alone.

Strictly speaking, it is not necessary to have both neat and sand tests in finding the strength of Portland cements; and, preferably, the sand test alone should be employed.

In the future only mortar mixtures in the proportions of 1 cement to 3 sand will be tolerated; and, moreover, I consider that these tests will not be reckoned entirely decisive, but compression tests on at least 3-in. cubes in the case of sand materials and 6-in. cubes in the case of concrete will be demanded for all purposes for which clear insight is desirable in the working of the material in actual construction. With the now increased demand for a finely-ground cement, therefore, it is to be expected, and, in fact, should be urged, that in place of neat tests an admixture of sand should be employed in estimating the value of the cement.

In the neat tensile test the full value of the cement as a concreting material or as a cementing power never comes into play; and granted that a finer cement is a more valuable product, a coarse sample in a neat test will give results as to tensile strength equal to those obtained by a fine cement. But, on the other hand, the difference between the constructive values of a coarse and a fine cement will be most noticeable in a test for tensile strength if carried out with a mixture of sand and cement in the proportion of 3 to 1.

The value of sand tests in the place of neat tests is more appreciated day by day, and this hardly requires an explanation, since cement is rarely, if ever, used in a neat state—except by consumers who have a wrong impression of its qualities. Therefore, in a sand test we obtain information of a much more practical value.

In the British standard specification both sand tests and neat tests are called for. Testing briquettes are prepared by gauging the cement upon a non-porous slab with a proper quantity of water into a smooth, easy-working paste. Then the cement gauged in this way is filled into the moulds or frames, as I now show here. When this cement has set sufficiently to enable the moulds to be moved without injury to the briquette, and which generally occurs after some twenty-four hours, the cement briquette is taken from the mould and put into a maturing tank of water for a period of seven and twenty-eight days, or even longer periods. Generally a number of briquettes are made up in this way from the same sample of cement, because it will be found that the test results are extremely variable according to the method of preparation, and therefore the average of, say, six briquettes is often taken to show the mean strength of the cement under test.

The briquettes are now tested in a tensile testing machine such as we have here. For breaking the briquette, it is held in strong metal jaws in the machine, and the load is steadily and uniformly applied to the 1 in. sq. section of the briquette, and starting from zero and increasing at the rate of 100 lbs. in 12 seconds in the case of neat cement briquettes, the weight is applied until the briquette breaks. The cement which passes the British standard specification must show an average strength of

400 lb. per sq. in. in 7 days,
500 lb. per sq. in. in 28 days.

In the case of sand tests the cement and sand briquettes must bear tensile stresses of 150 lb. after seven days from gauging, and 250 lb. after twenty-eight days from gauging.

A sand briquette is prepared from one part of cement to three parts by weight of dried standard sand, which is obtained from Leighton Buzzard. This sand must be thoroughly washed, dried, and passed through a sieve of 20 by 20 meshes to the sq. in., and must be retained on a sieve of 30 by 30 meshes.

In all tests of neat and sand briquettes it should be borne in mind that the briquettes must be immersed in water until ready for test. This arrangement is made because it is considered that the test is more severe with the cement under water than is the case if the briquette were left to dry in the air.

Much care must always be exercised in preparing briquettes for the tensile strength tests, for it is quite an easy matter to show very poor results with a good cement if the tester is a novice in the preparing of briquettes.

At the present time the section of a cement report which receives the most attention is that dealing with the tensile strength. This, perhaps, is not surprising when we remember that this test, although possibly the most illogical and erratic, is the most convenient.

The object of the tensile (or "stretching") test is to determine the greatest stress per sq. in. which, under given conditions, the cement can be made to stand without rupture. If the conditions have been carefully observed, and yet several discrepant results are obtained, the highest *may* be right, but the others are certainly wrong. No averaging should be done, although this is a practice regularly resorted to.

In respect to the uncertainties due to the personal characteristics of the tester and to the influence of local conditions, this test offers greater scope for error than any of the others considered. The most scrupulous care must be observed in the manipulation, and the tester should possess natural aptitude for such work.

The manner and place of keeping samples for testing also materially affect the tensile strength results; whether, for instance, the samples are kept in air-tight receptacles or remain exposed, the results from these conditions have as much effect, for as against, the neat tensile strength test, and especially has it been found to be the case that neat tensile tests err if a fixed quantity of water is used by the tester irrespective of the individual peculiarities in any particular brand of cement.

The experience of those who have spent a considerable part of their lifetime in testing cements seems to show that every brand of cement has its own distinct peculiarity which requires to be investigated and understood before it can be stated that any given result by the tensile strength test is a true and sufficient ascertaining of the value of the identical sample under test.

Part of this variation is, however, inevitable. The strength of Portland cement depends so largely upon the details of the method of testing, that variations in manipulation among a number of other and minor causes make an appreciable difference in the results, and the neat tensile test is therefore governed by many circumstances.

The following particulars include, perhaps, most of the common causes of divergent results in the tensile test:

(1) ***Due to the Cement.***—Whether the cement is fresh or has been aerated, and if the latter, the period of aeration.

(2) ***Due to Gauging.***—The amount of water used in mixing. The quality, character, and temperature of the water used in gauging. The temperature of the room. Whether the cement is hand or machine mixed.

(3) ***Due to the Preparation of Briquettes.***—Whether a skilled operator has been employed. Whether the mould is of wood or iron.

Whether the shape of the mould is variable, the method of filling, and whether the mould was filled at one or at several operations. Whether all air bubbles have been eliminated. Whether the mould is shaken, tapped, rammed or pressed to make the briquettes of various densities.

Whether the briquettes are kept damp during setting, and whether kept dry or in water during the period of test. Whether the briquettes are made by the same operator on the same day under the same conditions. The temperature of the water used for immersion.

(4) ***Due to the Testing.***—The temperature of the testing room. The length of time the briquettes have been out of the water previous to testing. The area of the breaking section. The form of the briquettes and the shape of the cross section at the point of fracture.

The nature of the strain, and whether suddenly or gradually applied, and the time occupied in applying the strain; the form of clips in the testing machine for holding the briquettes; the position of the strain as regards the breaking section of the briquettes and the preventing of cross strains; the unequal bearings of the clips on the briquettes, and so on, may we find innumerable possibilities for divergent results in the tensile strength test.

The fact that there are so many separate factors connected with the making and testing of briquettes, all of which have a distinct and definite influence on the subsequent tensile strength, need not, however, unduly point to the inconsistency of the test. For instance, the age of the cement after grinding is found to affect the tensile strength of a briquette, but as the manufacturer is responsible for the state in which the cement leaves his works, we can rely upon him looking after his own interests in this direction, and indeed many of the pitfalls, if not all, are soon obviated after a little experience.

The percentage of water to be used in the gauging of briquettes is generally from 18 to 25, a proportion which varies according to the age, fineness, and activity of the sample. For briquettes of three parts sand to one of cement, about 12 per cent. of water is required (the percentage being calculated on the total weight of the sand and cement). The best results are obtained with a minimum quantity of water, and a dry or stiff plastic mixture gives greater uniformity.

The water to be used in gauging must be clean and fresh, and of a temperature of about 60° to 70° Fahrenheit. In the gauging of briquettes the cement and water must be thoroughly mixed for one minute, and then pressed into the mould by the trowel used in gauging.

Any excess cement should be removed and the top of the briquette smoothed off level with the mould. Particular care should be taken that the mixing is carried out upon some non-absorbent substance, such as a slab or slate or thick glass.

The remaining tests outlined in the British standard specification are those for *specific gravity* and *chemical composition*. These two tests when required by the consumer are generally referred to consulting chemists. but are rarely carried out by engineers.

TESTS FOR SPECIFIC GRAVITY.

The specific gravity test some years ago replaced the old-time test of weight per bushel, which has been rendered useless and made obsolete by the present fine grinding of cement. So long as all cements were coarsely ground and about the same degree of fineness, the requirements of engineers that the cement should weigh a specified number of pounds per striked bushel was found fairly satisfactory when made workable by uniform methods in carrying out the test. When a heavy cement was required by the consumer, a heavy weight was stipulated with the weight per bushel test ; but as the demand for a finely-ground cement increased, the weight of 112 lb. to 120 lb. per bushel, once easily attained, cannot now be reached, and the weight of a well-burned ordinary cement ground finely enough to pass through a 76 by 76 mesh sieve will be about 105 lb. to 110 lb.

Portland cement possesses a very high specific gravity, on which its value as a mortar is based. All other cements have a smaller specific weight, and therefore cannot form a mortar of equal density and resisting power. The specific gravity of Portland cement varies between 2·90 and 3·20.

Owing to the absorption of water and carbonic acid (having specific gravities of 1·0 and 0·88 respectively), the specific gravity of cement decreases with age, or after aeration ; and although the specific gravity clause is at present a feature of almost every engineer's specification for cement, yet one can probably make no greater mistake than reject a cement on the ground of low specific gravity alone. A low specific gravity in cement is more often caused by the presence of water, combined or absorbed, and where a low test is found it should be at once discovered what is the cause of this condition ; indeed, since the absorption of moisture during the process of seasoning causes a considerable lowering of the specific gravity, it would be improper to condemn a cement for a quality that may be actually beneficial.

TESTS FOR CHEMICAL COMPOSITION.

In regard to the chemical composition of cements, it may be said that this test will render valuable services in the detection of adulteration, and it is of use also in determining whether certain constituents believed to be harmful in cements, such as magnesia and sulphuric anhydride, are present in admissible proportions.

The chemical analysis of cements, therefore, if taken in conjunction with the mechanical and physical tests, affords much desirable information in the selection of a good quality material ; indeed, it is almost necessary that both the chemical and mechanical examination of a cement should be made before the positive pronouncement of quality can be given, and when both have been ascertained, the suitability and efficiency of a cement for any given purpose can be at once accurately determined.

Since, however, this work of chemical analysis must be carried out by qualified chemists, and which is rarely called for, I will, therefore, also only give a passing reference to this test.

Where the chemical composition of a cement is decided to be taken, it is necessary that its analysis should comply with the British standard specification conditions, which arrange that the hydraulic modulus or ratio of lime to silica and alumina shall be not greater than the maximum nor less than the minimum ratio of 2·85 or 2·0 respectively calculated in chemical equivalents and represented by the equation—

$$\frac{CaO}{SiO_2 + Al_2O_3}$$

Further, the cement shall not contain a greater percentage of insoluble residue than 1·5, and the magnesia must not exceed 3 per cent.; sulphuric anhydride must not exceed 2·75 per cent. and carbon dioxide 0·5 per cent. Water in the sample shall not be in greater quantity than 2 per cent. of the weight of the cement.

Occasionally other tests are introduced by enthusiastic engineers, such as rise in temperature test, and cold plunge or immediate immersion tests, and again the contraction tests I have described ; but experimenting by faddists is to be deprecated, since many of such tests have no practical or theoretical relation either to the quality or uses of cement, and generally show merely physical phenomena, the bulk of which are due to faulty testing. It is preferable to adhere to only the tests as outlined in the British standard specification, since they comprise the most practical and useful inquiries which should be made ; these tests having been settled by a representative committee of experts most competent to judge the present-day requirements of cement in practice.

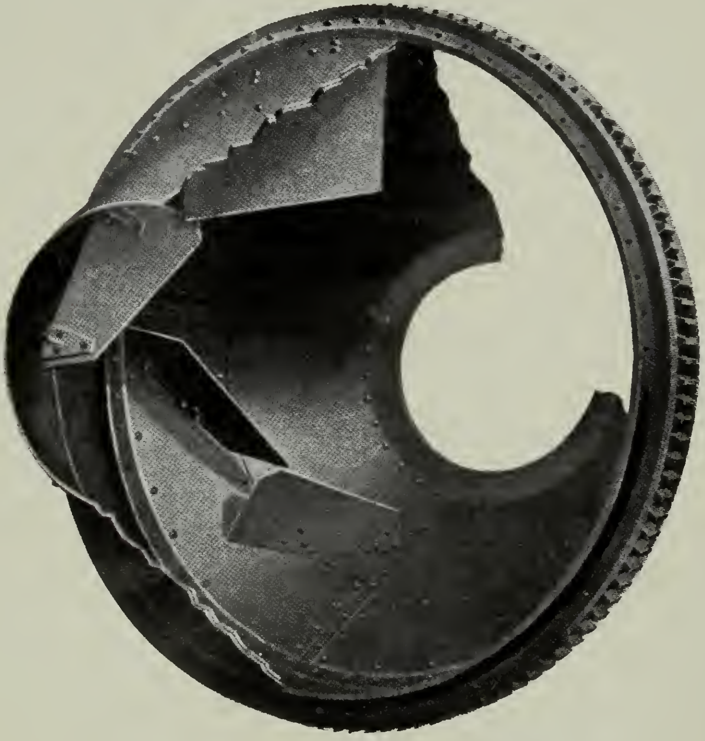
In determining the good qualities of cement for constructional purposes, therefore, it is imperative that the product should possess at least two essentials—the qualities of strength and soundness ; and the primary object of all cement testing is to determine whether the material is satisfactory in these two important particulars. The other theoretical tests for fineness, specific gravity, the time of setting and chemical analysis are of value only as the results give additional information as to the general suitability of the material.

It is a rather remarkable fact, and one that makes the study of cement testing most difficult, that the precision and accuracy possible in any one of the physical tests varies almost exactly inversely as the importance of that test. Thus, all would be willing to agree that soundness is the most essential quality for a cement to possess, and yet the ordinary tests for soundness are most inexact, and until the Le Chatelier test was introduced were the most dependent of all the routine tests upon personal judgment. In the test for strength, which undoubtedly comes second in importance, we have all the variations due to the personal equation in mixing, moulding, handling and breaking, which make this test rather one of experience than one of exact treatment. In the time of setting these inaccuracies are still further reduced on account of the simpler processes required. In the fineness test, which is far less important than any of the preceding, we reach the first test that is capable of some accuracy, or at least an accuracy that is measured more by apparatus than by experience in manipulating ; and finally, in specific gravity, which in itself has almost no importance, we reach the only test that can be considered as capable of precise determination.

In the testing of cements it might also be mentioned that in addition to the processes I have described—namely, the chemical and physical tests according to well-known standards and theories, the average consumer generally tests the qualities of cement by practical results, preferring to watch the action of cement in work rather than rely upon the qualities as shown by the laboratory records. However, this " practical " test, be it said, is far more likely to give erratic results as to the qualities of cements (and its consequences are likely to be far more serious) than is the case in any of the recognised tests I have mentioned. There are innumerable ways in which a perfect quality cement by faulty manipulation may be made to appear otherwise, and there are again many aggregates which destroy the otherwise sound qualities of many cements of approved first-class quality. Probably the most common cause of trouble in the use of cement is the failure to recognise the fact that the setting of Portland cement is a chemical process which may easily be retarded or destroyed by unfavourable conditions.

There is much room for education on the part of the cement user. He needs to know, first of all, what he really wants in a cement—that is, what properties are of special value in his work. With this knowledge will come a better realisation of the necessity not only for uniform methods, but what is more to the point—uniform tests. When he realises that because one brand of cement does not harden quite so rapidly as another it is not necessarily inferior for the average piece of work, and that the cement which fails to gain in tensile strength 12 or 15 per cent. over 900 lbs. from seven to twenty-eight days is not likely to suffer by comparison with average cements in any other way, and that when properly made and seasoned these cements are equally good for ordinary work (although one or the other may be superior for some special work) : when these facts are generally understood and appreciated, there will be no reason for a manufacturer to modify his test methods so as to make a given showing—to obtain predetermined results—and uniform tests will be advanced a long way.

This outline of the testing of Portland cements completes the information that it is advisable to obtain in using the product for any important engineering or constructional enterprise, and I will conclude my paper by showing on the screen some of the results obtained in a typical cement-testing experience.



Section of the Double-Conical Smith Drum, showing the Arrangement of the Mixing Blades.

CONCRETE MIXERS

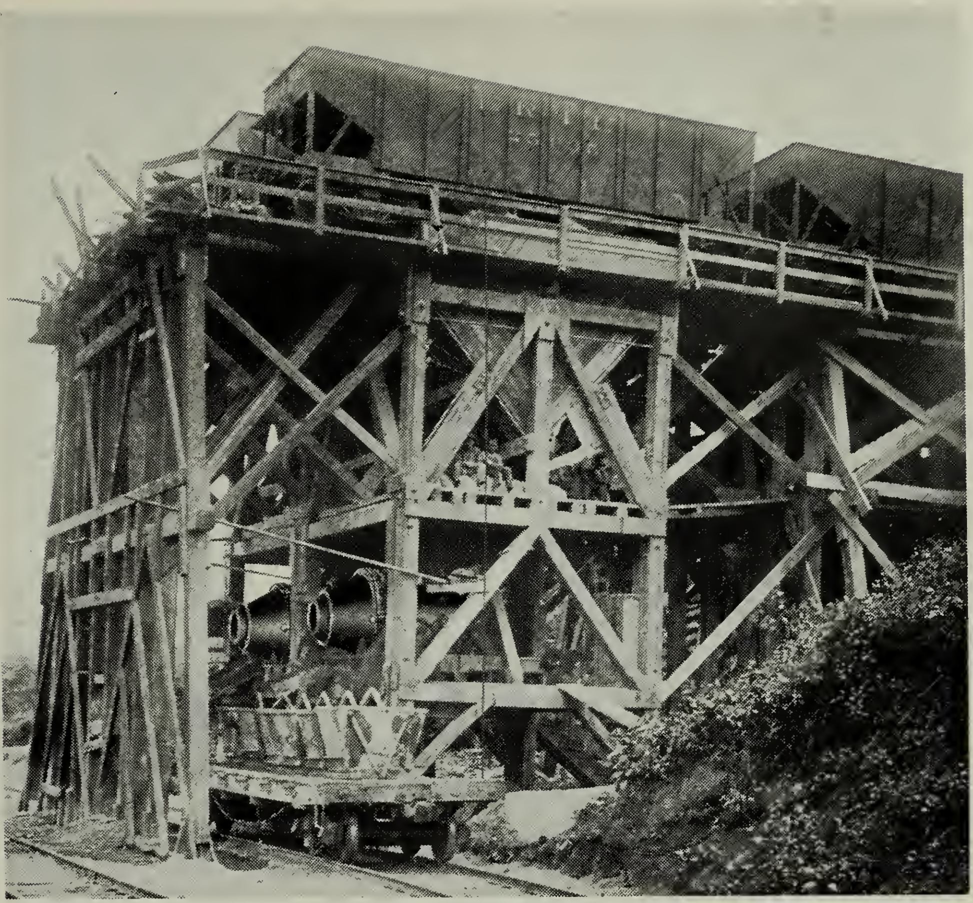
In some of our former issues we have been publishing articles on different appliances for concrete mixing, and the present pages are a continuation of the particulars presented, and are based on data kindly put at our disposal by the makers of the respective appliances, and indicate their views as to their efficiency.

The whole question of using mixers requires far greater attention than at present is accorded to this important subject. The economy of concrete and reinforced concrete work largely depends on the suitability of the machinery employed. Thus these contributions merit careful consideration.—ED.

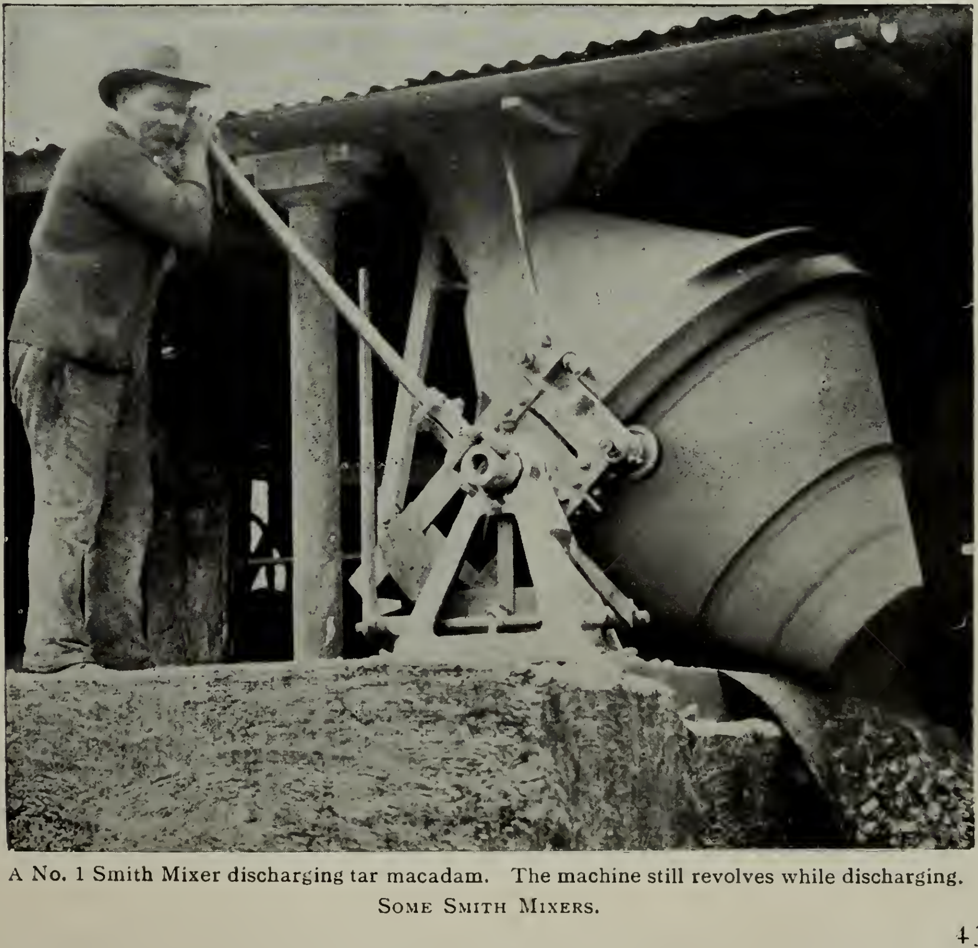
THE designing of a concrete mixer which will give the requisite number and kind of movements required for the making of good concrete is by no means a simple matter, as the long trail of failures has taught the manufacturer and the contractor to their cost. A concrete mixer must be designed to operate under the severest conditions, and the mechanical construction should therefore be of the best, while the great rapidity of output demanded for modern building operations calls for a machine which will mix and discharge a batch in the shortest possible time.

This article is illustrated by photographs of the Smith mixer, which in the course of the last ten years has proved itself to be a machine which in several directions has nearly attained perfection, and in which the underlying principles of concrete mixing have been clearly recognised, and have been very

A Smith Mixer on Truck, with Petrol Engine.



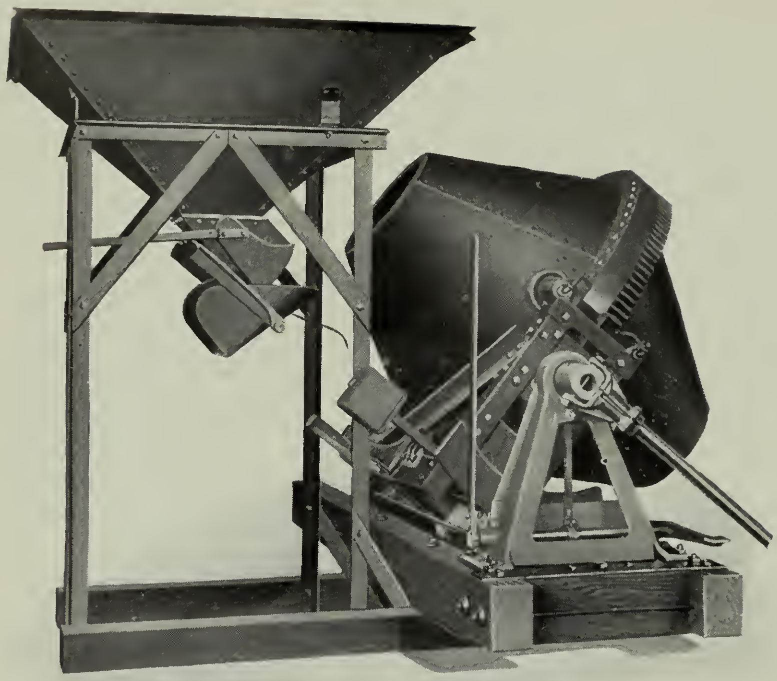
Two No. 5 Smith Mixers used on a plant at Alleguipa.
These two machines are estimated to turn out 1,500 cubic yards of concrete per diem.



A No. 1 Smith Mixer discharging tar macadam. The machine still revolves while discharging.

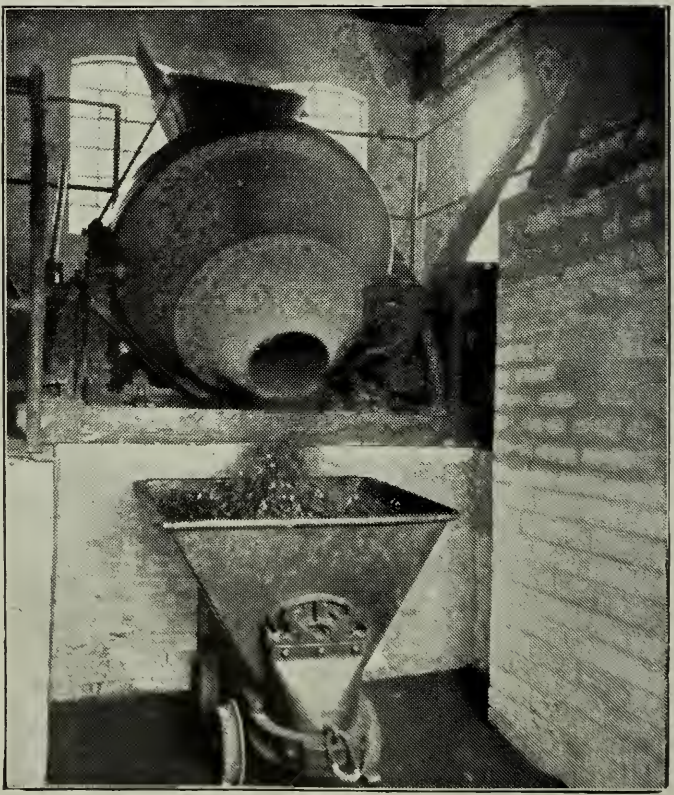
Some Smith Mixers.

successfully put into practical effect.



A No. 1 Smith Mixer, with Batch-charging Hopper. The chute from the hopper comes automatically into position when the drum is tilted back.

Even without its blades the double-conical drum of the Smith mixer will effect a mixture, for as the drum revolves the mass, while turning over, spreads out laterally at the top of the pile and is gathered together at the centre, thus rapidly mixing the contents together. The blades, which are set in a spiral, accelerate and assist the natural mixing movements of the material. They also heap the aggregates towards the centre of the drum and force them together. That there is an actual exertion of force in the crowding action of the blades is best illustrated by revolving the drum in the reverse direction, when it will be found that the materials are ejected from the drum, showing clearly that when running in the right direction the mass is driven in on itself. The extraordinary rapidity with which the Smith drum mixes its contents is accounted for by this complex action.



Front View of a Smith Mixer discharging tar macadam at the Tipton Council Works. The photograph was taken at the moment of discharge; the material can be seen falling into the truck.

One of the cardinal principles which should be recognised in the design of a concrete mixer is that no working parts should come in contact with the concrete. Cement is most destructive to bearings, and being a very fine powder, will work its way through the most accurately-fitted joints. There are no moving parts in the Smith drum, the whole receptacle revolves and all moving parts are set as far away from the filling and discharge openings as possible, and are adequately protected from possible contact with the concrete during its preparation.

The mixer is discharged while running by tilting, and the contents are thrown out of the drum with such rapidity that the discharge is almost instantaneous.

The Smith mixer was primarily designed for making concrete, yet it has been found to be suitable for mixing almost any materials, wet or dry. It has proved itself suitable for making tar macadam. It prepares and discharges a perfectly-mixed batch of tar macadam in an extraordinarily short space of time. It is also used for mixing the different sands used in glass factories, core sand in foundries, fertilisers, chemicals in chemical works, and, in a word, any materials, provided they are not too sticky, which need to be thoroughly mixed together irrespective of their specific gravity.

The machine was, we believe, invented by Mr. T. L. Smith, the chairman of the T. L. Smith Co., whose London office is at 11 Victoria Street, and it is manufactured in England by Messrs. Stothert & Pitt, of Bath, under agreement with the T. L. Smith Co.

THE BUILDING TRADES EXHIBITION, OLYMPIA.

II.

In continuation of our article of last month, we now have pleasure in writing some further particulars of this Exhibition, which was held April 22nd—May 6th.—ED.

Last month we described the cement and concrete exhibits at the Building Trades Exhibition, but our notice had to be prepared in advance of the actual opening day, owing to the exigencies of going to press. We now supplement our former article with a few additional particulars of some exhibits of concrete appliances which we did not deal with before, and also give an account of various classes of exhibits for which we had not space in our last issue.

The Exhibition was well visited by the general public, as, too, by a number of technical societies, among them being the Concrete Institute. On the whole, we feel it was a little disappointing as regards the cement industry, though it well maintained the reputation of former years in respect of other trades connected with building. The Exhibition was larger than any previous one, and had just as much variety in the subjects with which it dealt, but the interest was mainly in regard to other trades than that of concrete and fire-resisting construction.

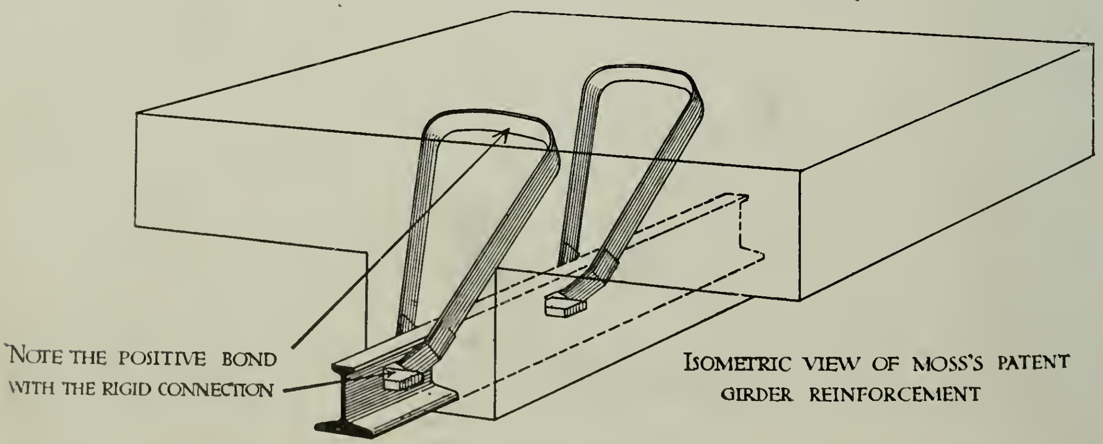

NOTE THE POSITIVE BOND WITH THE RIGID CONNECTION
ISOMETRIC VIEW OF MOSS'S PATENT GIRDER REINFORCEMENT

Fig. 1. Moss's Patent Reinforcing Bar.

REINFORCED CONCRETE.

In our first notice we said that there were two new reinforcing bars in the Exhibition, but we find that at the stand of the Nostell Brick and Tile Co., ***Messrs. William Moss & Sons'*** special bar was shown, which was also new to the Building Trades Exhibition. The form of this bar is shown in *Fig.* 1., and will be seen to consist of a small modified I joist, in the web of which stirrups are inserted ; thus rigid attachment and proper positioning of the stirrups can be ensured.

Messrs. Hubert Todd & Co. showed some interesting applications of concrete and reinforced concrete, in particular some concrete manhole covers made in stock sizes. The form of these manholes is shown in *Fig.* 2. It will be seen that the cover drops into a splayed rebate which is quite tight. A good many such covers have been used, and have been found perfectly serviceable. Another speciality shown was a concrete horse-watering trough, which is a somewhat novel application, but a quite useful one. Messrs. Todd showed, too, samples of their granite concrete pavings, artificial stone, and of the reinforced concrete work that they have carried out.

Mr. George Blay showed some reinforced concrete fence and gate posts, for which he is evidently finding a market, although he is chiefly known for his oak, jarrah, larch, and other fencing, and his timber gates.

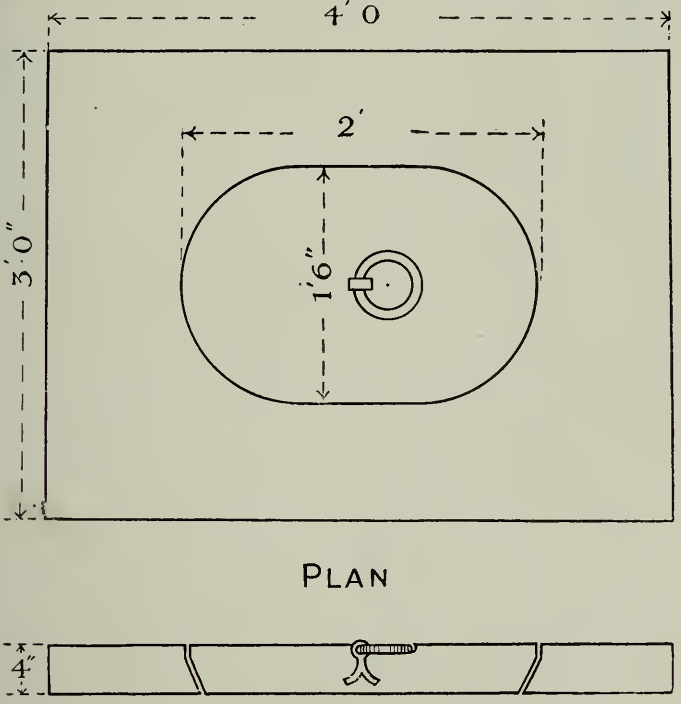


FIG. 2. HUBERT TODD & CO.'S CONCRETE MANHOLE COVERS.

CONCRETE.

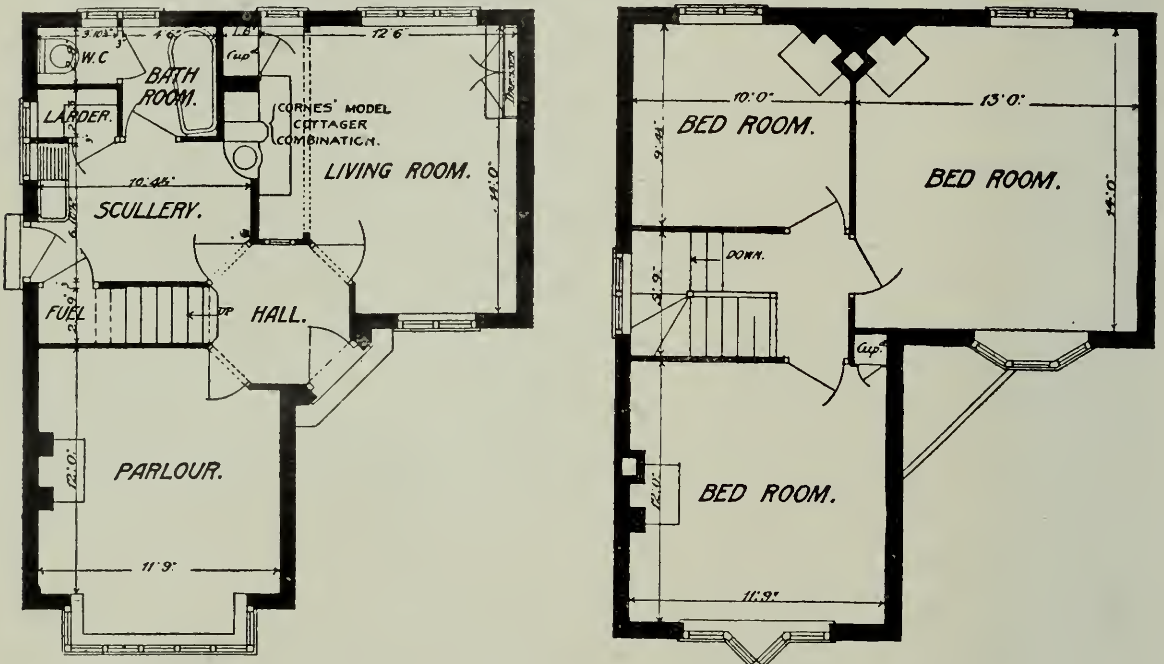
Many materials for concrete were shown in the Exhibition. We may refer to the exhibit of ***Mr. Frank Keep,*** who showed various kinds of clinker, breeze, and coke-breeze. Care should be paid to the supply of these materials for concrete work, and with this in view the grading and the source of supply are carefully watched, so as to provide reliable material as far as possible. The breeze is carefully washed and the materials are separated, so that one can purchase materials customarily looked upon as doubtful to a grade which will be serviceable for concrete work. Samples of broken brick were also included in this exhibit.

Other materials for concrete exhibited were stone from the ***Northern Quarries Co., Ltd.,*** and trass, pumice, and gravel by ***Messrs. Bristowe & Co., Ltd.*** This latter firm, by the way, also exhibited the " Whalley " mixer, which is applicable to either concrete or tar macadam. ***Messrs. John Wainwright & Co., Ltd.,*** exhibited basalt, quartzite, black rock, and limestone.

Messrs. Cornes & Haighton's exhibit of a model cottage constructed of concrete partition slabs made by ***Messrs. J. A. King & Co.*** was undoubtedly a very attractive feature of the exhibition. The cottage had a living room, parlour, and scullery, with three bedrooms, and the cost was £150 to £200. Our illustrations herewith (*Figs.* 3 & 4) show the ground-floor and first-floor plans.

MIXERS AND MACHINERY.

An excellent type of block-making machinery was in evidence (*Fig.* 5), manufactured by the ***U.K. Winget Concrete Machine Co., Ltd.,*** Newcastle-on-Tyne. The striking feature of this machine is its simplicity of construction by the elimination of complicated parts and unnecessary operations. Only two motions are required to work it—one pull of the lever to close the machine ready for filling, one more to open it again, and then the blocks are ready to be taken away. It can also be utilised for making blocks face down without any alteration, the only action necessary being to withdraw a spring bolt and the machine swings on the side. When the face is made the machine is swung back and block is finished. The machine is a complete plant, portable, and no power is required. There is no need to buy a special machine for different sized blocks or partition slabs. The one machine is capable of making all, with the necessary accessories and parts, which are machined and made interchangeable, so that a perfect fit can be insured, and they can be changed in a few seconds to suit the different kind of blocks required. It is capable of making blocks ranging in lengths from 4 in. to 32 in ; width, $2\frac{3}{16}$ in. to 16 in. ; heights, 3 in. to 12 in., including angle blocks, returns, corbels, skirtings, quoins, string courses, spout corbels, gate piers, chimney flues, water tables, copings, kerbs, channels, etc. It can also be arranged to make three partition slabs at one operation, 28½ in. long, 6 in. to 12 in. deep, and either $2\frac{3}{16}$ in.,



Figs. 3 and 4. Plans of Messrs. Cornes & Haighton's Model Cottage.*

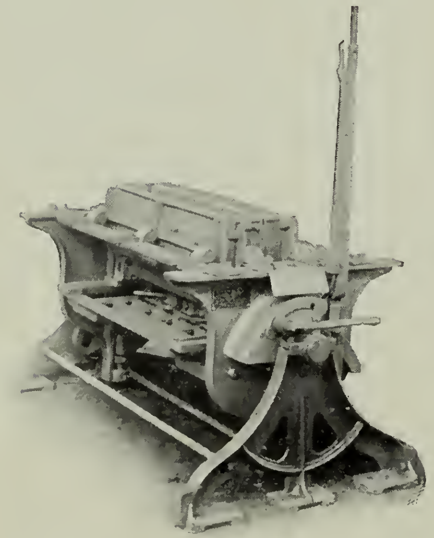


Fig. 5. Winget Block Machine.

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* These blocks were kindly put at our disposal by the *Municipal Journal.*

$2\frac{13}{16}$ in., or $3\frac{13}{16}$ in. thick ; also 2 hollow slabs $4\frac{3}{8}$ in. thick, with one pull of the lever. Each of these partition slabs has a male and female vertical joint. The average output of 32 × 9 × 9 in. blocks is 400 per day of 10 hours, while 120 partition slabs, $28\frac{1}{2}$ in. × $2\frac{3}{16}$ in., are being obtained from the one machine in one hour. The machine can be worked by unskilled labour, as there are no parts to get out of order.

The Express Mixer was also shown by the same firm. This has a circular fixed pan with revolving arms upon which are attached eight adjustable ploughs and rakes. The action of the ploughs is to turn the aggregate over, as a shovel would do in the case of hand mixing. Each plough is followed by a rake which spreads the aggregate over the bottom of the pan. This is repeated until the mix is complete. There is no chance of the aggregate balling, thus insuring a proper and perfect mix. The pan is self-delivering, by two sliding shutters in the bottom.

We may supplement the particulars of the ***Ransome ver-Mehr Machinery Co.*** by referring to their corrugated sheet piling, for temporary or permanent work, which they had on show. It is manufactured of pressed steel sheets, and the corrugations are driven to overlap and provide a close sheeting. Another of their exhibits was a cement testing machine, in which the Smith-Edwards method of boring through a test block and measuring the resistance of the block to the drill by means of a spring balance is employed. In this method the penetration corresponding to the resistance is measured automatically on a scale and read off in millimetres, and the hardness of the cement at any depth in a test piece of any age may be accurately determined, thus indicating whether a particular cement in setting is merely hardening on the external surface exposed to the air or hardening uniformly through the whole mass, as should be the case for reliable work ; in fact, it discriminates between setting and hardening, terms often considered to be synonymous, but which experiment proves to be totally different. The method indicates a quick-hardening cement as distinct from a quick-setting cement, and indicates definitely when hardening has progressed sufficiently to enable centering or shuttering to be removed safely. Another appliance was the Vibrant consolidator, a mechanical tamping machine (*Fig.* 6). By rotating the handle, which is on a different standard, arms are arranged on a wheel hammer on the base of the rammer so as to cause the same to vibrate, which it is claimed will do away with voids, and at the same time increase the crushing strength of ordinary well-rammed concrete. Though not shown, particulars were furnished of the Ransome aggregate conveyor, which enables large quantities of concrete to be handled, the aggregate being taken from any type of truck, waggon, or cart, gauged and delivered to mixer with only one handling charge. The conveyor belt runs under a number of hoppers with drop doors from which the materials are discharged in properly measured

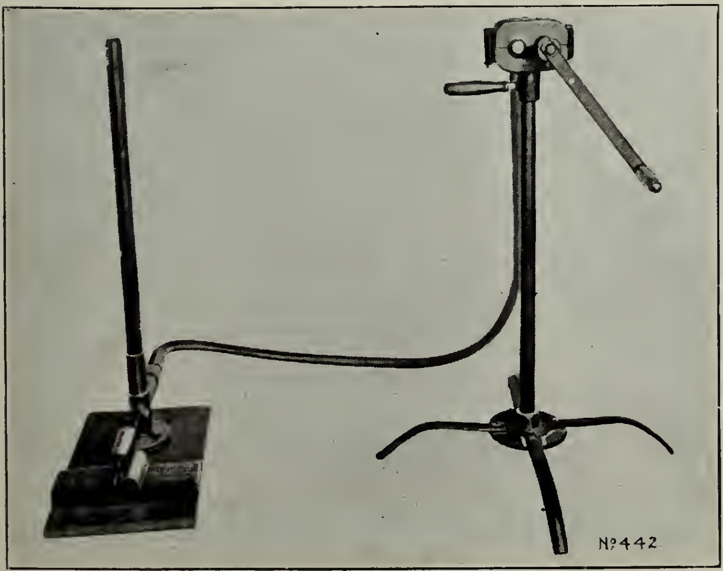


FIG. 6. THE "RANSOME" VIBRANT CONSOLIDATOR.

proportions, and thus the materials come to the mixer already gauged, so that the latter can be operated at full speed. It is often extremely important that sand and aggregate should be washed, and two forms of washers are supplied—the " Mercer " and the " Odgen." In the former two tubes are provided, from one dirty water being discharged, and from the other sand or aggregate. The clean water enters at the upper end, and the sand is carried up against the stream of water by a worm conveyor, emerging from contact with clean water only. An output of 70 to 100 tons per day is given with an expenditure of 3 h.p. In the " Odgen " washer the materials are elevated to a jigging screen upon which water is sprayed from perforated pipes, the fine material falling through this jigging screen on to another screen that distributes the sand into one truck and the dirt into another, while the material running off the end of the jigging screen falls upon another screen which grades the material into large and medium. This latter, it may be mentioned, has been put to successful use at sewage disposal works.

Messrs. J. Pickles & Son showed their " Holcrete " concrete block machine, suitable for making blocks of various sizes. In addition, they exhibited a special hand-operated batch mixer, a special sill and lintel moulding machine, " Holcrete " sewer and drain-pipe moulds, and the " Ideal " cement-sand block machine, the last named making 10 or 20 blocks at one operation, and turning out 3,000 or 6,000 blocks per day.

CEMENT.

The Barnstone Blue Lias Lime Co., of Nottingham, showed their Portland cement, and their blue lias ground and lump lime. They also exhibited a material for plaster called " Murite," and a material called " Vianex," which is used for binding macadam roads. This material is a lias lime, and is mixed with the road-surfacing material, which is rolled in place the same as ordinary macadam. Water causes the lime to set and bind the road together, so that one obtains a kind of lime-concrete road surface. The lime is, however, more pliable than cement would be, and thus gives an elastic road that wears well. Existing roads can be scarified and coated with a layer of " Vianex " and chippings.

ROOFING.

We mentioned in our last issue a number of roofing materials which are often used in connection with concrete. We now supplement these with particulars of other roofings.

The Binfield Brick and Tile Co., Ltd., are making various tiles. ***The Hazlewood Brick Co.*** exhibited hand-made, sand-faced red roofing tiles, and tiles made to match old tiles. They also supply machine-made, partial sand-faced tiles, together with ordinary ornamented and ridge tiles of various descriptions. The ***Ravenhead Sanitary Pipe and Brick Co., Ltd.,*** showed examples of their manufactures, which include clinker paviors, pipes and bricks, as well as tiles.

This firm also showed the " Ravenhead " rustic-faced brick—clean, hard bricks giving the appearance of well-preserved age on a new building.

The Towers Adamantine Clinker Fire and Roofing Tile Co. showed paving bricks and firebricks, as well as roofing tiles. ***Messrs. T. Pascall & Sons*** exhibited their hand-made, sand-faced roofing tiles. The ***Nostell Tile & Terra Cotta Works*** showed examples of terra-cotta construction and faience and fireplaces, in addition to their roofing, floor, and wall tiles. ***Messrs. Colthurst, Symons & Co., Ltd.,*** showed interlocking and plain tiles. ***Mr. Thomas Mitchell*** exhibited hand-made, sand-faced tiles. ***Messrs. S. & E. Collier, Ltd.,*** supply both old-fashioned, hand-made tiles and glazed Italian tiles and ridges of a variety of patterns, terra-cotta and chimney-pots.

Messrs. D. & C. Rutter, Ltd., also supply hand-made tiles and terra-cotta partition blocks and hollow tiles for floors. ***Messrs. H. J. & C. Major, Ltd.,*** showed their well-known interlocking roofing tiles.

The Oakeley Slate Quarries Co., Ltd., had a working exhibit, in which they showed the entire process of manufacturing the finished slate from the rough block. Their quarries have been working for upwards of 200 years now, and immense quantities of these slates have been used.

Messrs. Roberts, Adlard & Co. showed various examples of English slating in red, fawn, and green, and also examples of stone slating. In addition, they showed some foreign green slates, Welsh slates of various kinds, together with roof tiling and oak shingling, wall and floor tiling. Slate masonry also came within their purview.

Messrs. F. McNeill & Co., Ltd., showed their asphaltic roofing and sarking felt, and bituminous felt for roof lining and sound-deadening purposes. Several of their special varieties are of inodorous felt free from offensive smell. They make a pure Trinidad Lake bitumen damp-course and sheeting for lining concrete tanks, covering concrete roofs, etc. They also exhibited their patent slag wool for fireproofing and sound deadening. Among the sheet roofings which Messrs. McNeill supply is a 3-ply combination roofing material for forming flat roofs that can be used as gardens or playgrounds, and also a material which is supplied in handy rolls for easy application.

DOORS.

We have referred above to certain aspects of fire-resisting construction, and this leads us to mention the subject of fire-resisting doors.

An interesting fire-resisting door was that called the " Dreadnought," shown by ***Fireproof Doors, Ltd.*** This is made of steel sheets, in which panels or grooves are pressed to allow of expansion or bulging. Two of these doors have been tested by the British Fire Prevention Committee, with excellent results. Another steel door was that shown by the ***Art Metal Construction Roneo, Ltd.*** This was a new form of construction that has not yet been tested from the fire point of view, but seems to have good points. The steel plates on the door were fastened in a frame which had room for them to expand under heat. A noticeable feature of this exhibit was the enamelled finish which led one to suppose that the doors were of finely figured wood. This firm emphasised the fact that in supposedly fireproof buildings one generally finds a great number of wooden fittings—window and door frames of wood, and furniture of an inflammable character—and they exhibited fittings, counters, and furniture of every kind made out of pressed steel, which certainly had a handsome appearance. Another firm showing metal furniture was ***The Adjustable Shelving and Metal Construction Co., Ltd.,*** who, in addition to their steel shelving, exhibited shutters, lockers, cabinets, card index drawers, and light " fireproof " safes. ***Messrs. Henry Hope & Sons, Ltd.,*** exhibited kupronised steel doors glazed with fire-resisting glass. ***Messrs. Phillips & Son,*** in addition to showing their strong rooms and safes, exhibited party-wall iron doors and strong-room doors. ***Mr. John Tann*** also showed safes, strong-rooms, and fire-resisting doors. ***Mr. John P. White*** had on view a patent hospital fire-resisting door of wood. ***The Wilson Rolling Shutter Co.*** exhibited their corrugated rolling steel shutters and partitions, which are formed of interlocking slats which expand without buckling, and which have been shown not to get out of working order during fires and to adequately protect openings. Special arrangements are made for automatically closing such shutters in case of fire. The Wilson shutter has been subjected to a series of fire tests by the British Fire Prevention Committee. ***The Hempstead Patent Brick Co.*** exhibited a door of a different character, consisting of their special porous terra-cotta partition blocks set in an iron frame.

GLAZING.

Among the exhibits we discovered "Ferro-Glas" (*Fig.* 7), which for novelty and practicability surpasses anything we have seen in glass construction, and unless we are mistaken we have here a new departure in the use of glass which seemed impossible.

It was at Stand 111—***J. A. King & Co.***, 181 Queen Victoria Street, London, E.C.—that we took a mental photograph of its great possibilities, which, amongst others, includes pavement and stallboard lights, roof, floor and dome lights, windows and borrowed lights, partitions, lantern and lay lights, etc., etc.

Briefly, it may be described as being made up of translucent glass blocks in all possible sizes and thicknesses, assembled and reinforced with mild steel rods and cement mortar, giving in the case of all horizontal constructions a crystal glass ceiling with practically invisible joints, and at the same time a weight-carrying construction. The advantages of thus combining floor and ceiling together with artistic effect need no further comment.

The advantages claimed are fire resistance, great bearing strength, minimum expense for maintenance, maximum light, no shadow cast as in iron-frame construction, no painting necessary, no iron to rust, easily cleaned, rapid construction, artistic effect.

Another interesting construction of a somewhat similar nature was the "Ferrostone" glazing bars, manufactured by the **British Stone and Marble Co., Ltd.** (*Fig.* 8.) Though not made of concrete, they are made of reconstructed stone, and greater life than the ordinary glazing bars is claimed for them, as also greater fire resistance. The manner of making these is interesting. The waste chippings of any suitable building stone are crushed to a granular state. This grit is then mixed with a definite proportion of lime made from dolomite, which has been calcined in closed retorts. The mixture is slaked and applied in a mould round the reinforcing steel bars. The whole is then subjected to a total pressure of eight thousand tons in a special hydraulic press, and the slabs when they leave the same are of the consistency of soft chalk, and therefore easy to work. Before hardening sets in these slabs are formed into separate bars of the required section by means of a special machine, and the bars are next dried at a temperature of 100° to 120° Fah., being then placed in steel tanks from which the air has been exhausted. Here they are subjected to the action of carbonic acid gas, obtained from the calcination of the dolomite above referred to, until the hydrate of lime is completely carbonated.

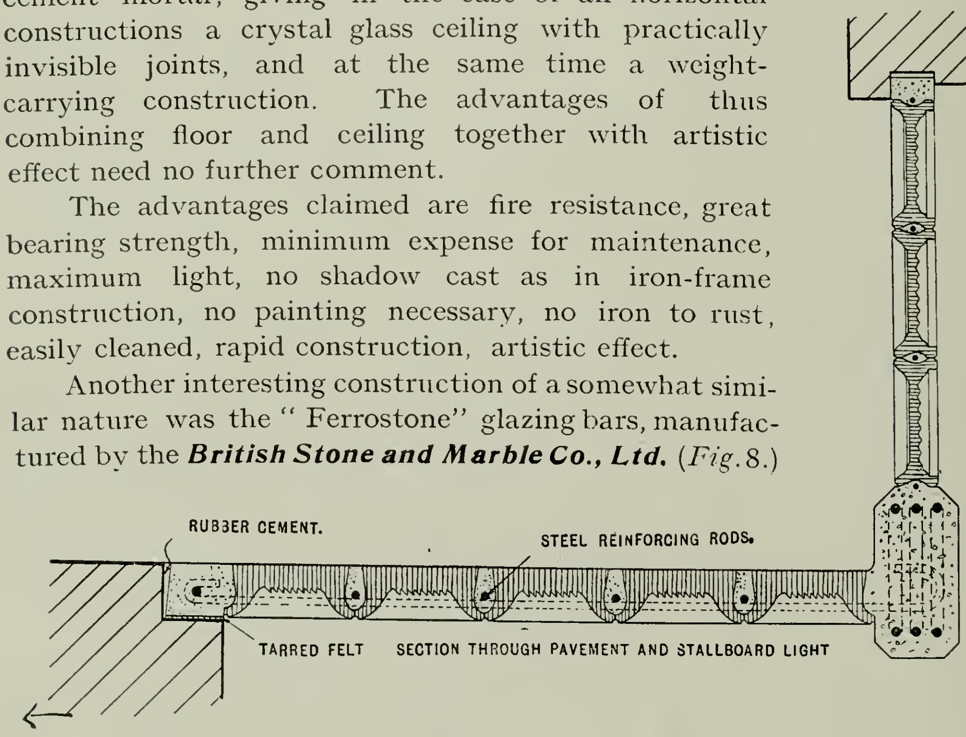


FIG. 7. MESSRS. J. A. KING & CO.'S "FERRO-GLAS."

While on the subject of glazing, reference may be made to the exhibit of **Messrs. Pilkington Brothers** of wired glass for fire-resisting purposes. This, in a sense, is reinforced glass, reinforced both for the purpose of strength and to resist fire. When subjected to heat the glass, of course, cracks, but cannot fall out because of the embedded meshwork of wire. The result is that the glass will not cause damage by falling, and flames are not permitted to pass, so that a draught of air which might fan the flames is obviated. It may be remembered that this form of glazing passed several severe tests at the British Fire Prevention Committee's testing station. Wired glass is now used extensively in places where it might possibly be fractured in an accident, and ordinary glass would be liable to cut persons and cause serious injury, if not loss of life.

GENERAL.

Concrete buildings are often faced externally either with rough cast or plaster of an ordinary character. A form of such decorative treatment was shown by **Mr. Masters Binning**, called "Stonament." The material is applied on the surface of concrete or stonework *in situ*, and gives the appearance of newly worked stone. It is advocated for renovating old buildings, and for the finishing of reinforced concrete structures. Any form of stone dressing can be imitated, or rough-cast, pebble dashing, etc.

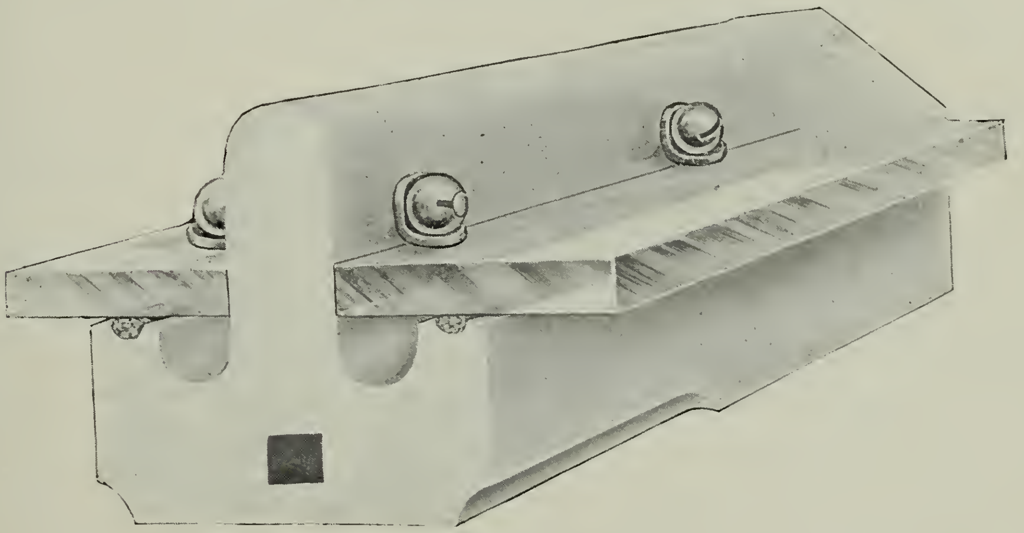


FIG. 8. THE BRITISH STONE AND MARBLE CO.'S "FERROSTONE" GLAZING BAR.

Among the general trades we noted a new system of scaffolding shown by the **Fuller's Patent Scaffolding, Ltd.** In this particular system there are neither cords, braces, or wedges, and the timbers are not cut, but can be utilised over and over again without waste. It is claimed that by this system 50 per cent. of labour is saved, while the cost of cartage and storage is reduced to a minimum.

Messrs. Colliers, Ltd., exhibited some plain tiles from their Marks Tey works; this firm also showed samples of their Cranham fireproof partition blocks and fixing blocks made of porous terra-cotta. These could also be supplied suitable for reinforced concrete floors.

Messrs. Carter & Co., Ltd., showed encaustic tiles for wall and floor decoration; **The Willesden Paper and Canvas Works, Ltd.,** supply their special underlining for slate and tile roofs; the **Patent Waterproof Materials Co.** also exhibited underlining papers; **Messrs. Mellowes & Co., Ltd**, showed their well-known patent Eclipse glazing, which has been on the market for a good many years.

Among the plasters shown at the Exhibition were " Sirapite," by the ***Gypsum Mines, Ltd.;*** " Murite," by the ***Barnstone Blue Lias Lime Co.;*** " Xelite " and " Xelstone," by ***Clark & Co.;*** and " Ivoril," exhibited by the ***Ivoril Plaster Co.***

For surfacing concrete floors, " jointless " floorings, so-called, are often employed. Two examples shown at the exhibition may be noted — namely, " Marbolith," by ***Messrs. J. Sperni & Co., Ltd.,*** and " Cork Adamant," shown by the ***Havana Exploration Co., Ltd.*** Messrs. J. Sperni & Co., Ltd., also showed examples of their terrazzo mosaic paving.

Messrs. A. C. W. Hobman & Co., which firm was established in 1874, showed specimens of their artificial stonework and concrete mosaic pavings and stair-treads.

ROADS

In connection with concrete bridges we are directly concerned with road materials, and as this forms a necessary part of highway construction, and many of our readers are municipal engineers who are specially interested in roads, we deal also with this subject. The direction of modern road construction seems to be in the allaying of the dust nuisance, and the provision of a more even and a more durable road by waterproofing the surface, or the material of which the road is composed, with a composition of a flexible nature. As regards materials entering into the general composition of roads which are treated in some way, there are the several kinds of tarred or asphalted macadam. The ***Trinidad Lake Asphalt Paving Co., Ltd,*** called special attention to the roads of macadam laid by them with a matrix or cementing material consisting of refined Trinidad Lake bitumen specially prepared for the purpose, the aggregate in these roads consisting of broken granite, limestones, or broken clinker. The asphalted macadam is laid in various depths from 1½ in. up to 4½ in. " Lithomac " is a composition of the ***Limmer Asphalte Paving Co., Ltd.,*** of " lithofeltic " material mixed with either whinstone or granite chippings. " Lithomac " is laid *in situ* whilst in a heated state, on a prepared foundation of any existing macadam road which can be rolled to a solid surface. This company also supplies " Lithofelt " paving blocks, which are used for street paving. The Brodie system is another form of macadam road, which was shown by ***Taroads Syndicate, Ltd. Messrs. Tarmac, Ltd.,*** showed their tarred slag for macadam roads ; this system has been very extensively used throughout the country. " Rocmac, Ltd." though it contains neither tar, pitch, nor oil, is a solution which forms in combination with crushed limestone a binder for roads. " Roadoleum Asphalt " was also shown, and is supplied as a dressing and binder for macadam roads by the ***Anglo-American Oil Co., Ltd.;*** whilst another binder shown was " Ferromac," made by ***Roadite, Ltd.*** The other road surfacing materials are mostly of the nature of tar sprayed on to the surface of the road by means of various machines, such as those shown by ***Messrs. W. Weeks & Son, Ltd., Bristowe & Co., Ltd., H. V. Smith & Co., Ltd., Ames, Parker, Ltd., Llewellins & James, Ltd.,*** and ***Johnston Brothers.*** The materials of this nature which were shown consisted of Clare's " Tarco," by ***Taroads Syndicate, Ltd.;*** " Tarvia," by ***Bristowe & Co., Ltd.;*** and " Glutrin," by the ***Robeson Process Co.*** These materials are a cheap expedient for preventing roads dusting, and increase the durability of the roads. Another material to prevent dust is " Akonia," which is either sprinkled on the road as a solution, or dusted on the road surface in the form of dry powder. This material, which is supplied by ***Akonia, Ltd.,*** is hygroscopic—*i.e.*, it absorbs moisture from the air, and so constantly keeps the road surface damp and prevents dusting.

SOME FOREIGN BRIDGES

DESIGNED ON THE HENNEBIQUE SYSTEM.

By ERNEST R. MATTHEWS, F.R.S.(Ed)., A.M.Inst.C.E.,
Borough Engineer of Bridlington.

A number of notable bridges have been designed on the Hennebique system, and, having regard to their importance, we have accorded them a special article which, apart from the highly interesting technical data, indicates the wide field covered nowadays by reinforced concrete. The article should be instructive reading to those who have to decide on the type of bridges to be used in our islands.—ED.

The author proposes in this article to describe some of the best examples of reinforced concrete bridges designed and erected on the Hennebique system. He will deal only with bridges of the arch type, as this is the class he recommends wherever it is practicable to erect such a bridge.

Arch Bridges.—The ribbed arch construction of Hennebique has been employed in some of the longest span arches ever built, one of the best examples being the three-span highway bridge built in 1903 over the River Aisne at Soissons, France. The spans are respectively 24·25m., 24·48m., and 24·25m. The Chatellerault Bridge, France, is another excellent example; this is one of the longest span arch bridges erected in reinforced concrete. It has been constructed over the River Vienne, and was erected in 1899. It has a centre span of 50m. (164 ft.), and two side spans of 40m. (131 ft.) each; the total length of the bridge being 443 ft.

Practically every system of reinforcement is adaptable to arch construction. This type of bridge is also very much more graceful in appearance than the ordinary girder type, and quite as economical.

Advantages of Reinforced Concrete in Bridge Construction.—These may be summed up in a few words. Reinforced concrete bridges are:

(1) Economical as regards first cost, a considerable saving being effected over other materials, such as steel, brick, and stone, or a combination of these materials.

(2) Upkeep is practically nil, while in other materials this is a considerable item.

(3) More graceful in appearance than steel trusses, or girders.

(4) Can be erected in shorter time than when any other material is employed.

(5) Proof against earthquake shock and fire.

(6) Any slight settlement of the foundations is less likely to affect a bridge built of this material than when in any other.

Hennebique Bridges.—The author will now describe several typical reinforced concrete arch bridges, all of which have been constructed on the Hennebique system. He will first deal with a viaduct built for the Pennsylvania Railroad Company.

(*a*) ***Viaduct at Scenery Hill, Philadelphia.***—This viaduct was built in 1909. It spans the railway line, and is entirely of reinforced concrete. It is illustrated in *Fig.* 1, and is a light and elegant structure. The arch has a span of 33m., and the roadway carried by the bridge is 32m. above the rails. It might be mentioned that the work was carried out by the Hennebique Construction Co., of New York, who have erected many bridges in the States. The bars used as reinforcement were plain, Hennebique stirrups being hooked to these as a secondary reinforcement.

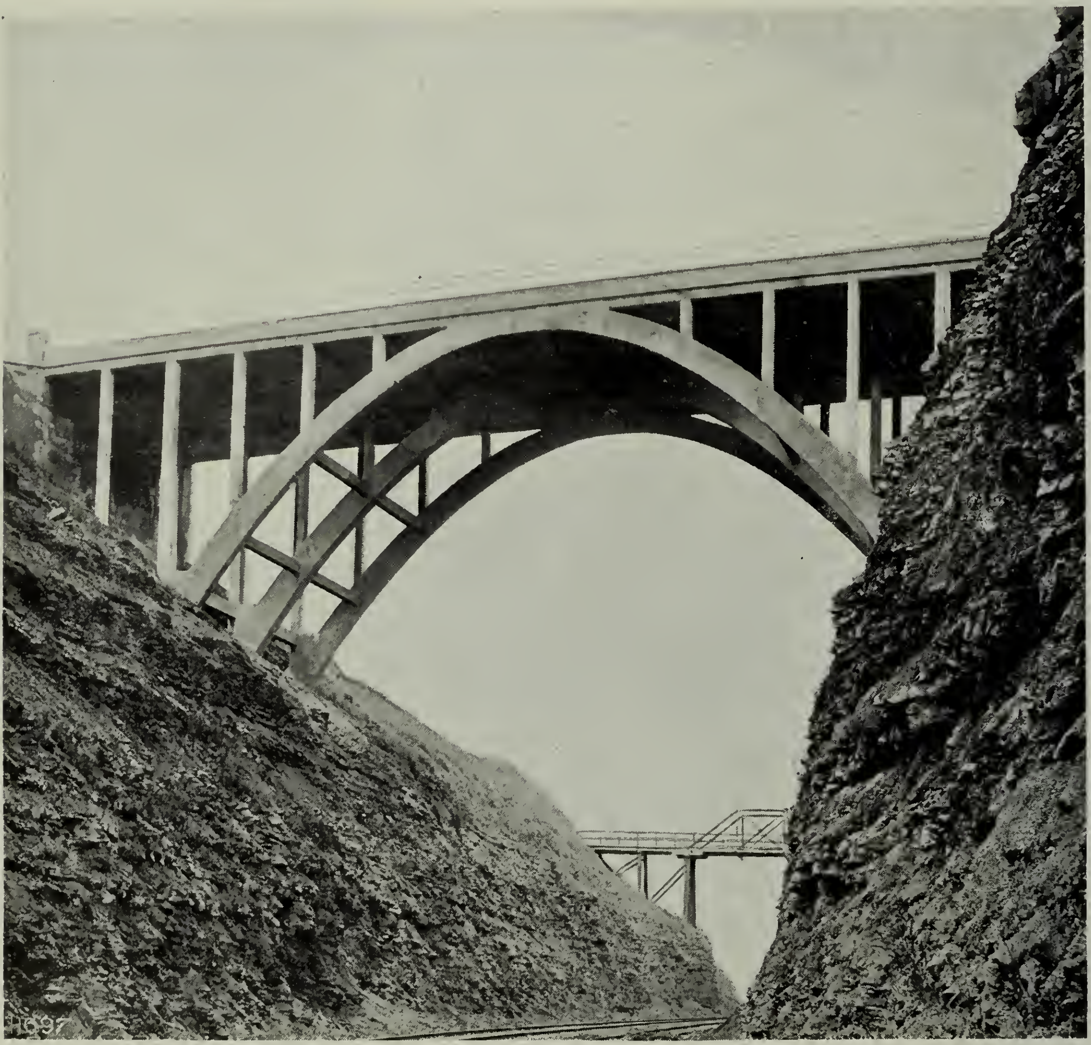


Fig 1. Reinforced Concrete Viaduct at Scenery Hill, Philadelphia.

(*b*) ***Bridge at Oliveira de Prades, Portugal.***—This is illustrated in *Fig.* 2, and consists of an arch of 32m. span, which connects the rocky sides of the Vouga. A steel bridge was practically out of the question in this case, as there were no roads giving access to the spot, and there would therefore have been great difficulty in transporting—a distance of 55 kilometres—the heavy pieces of steel forming the various parts of the bridge. It was also thought that stone was unsuitable owing to the severe floods which frequently occur in the river,

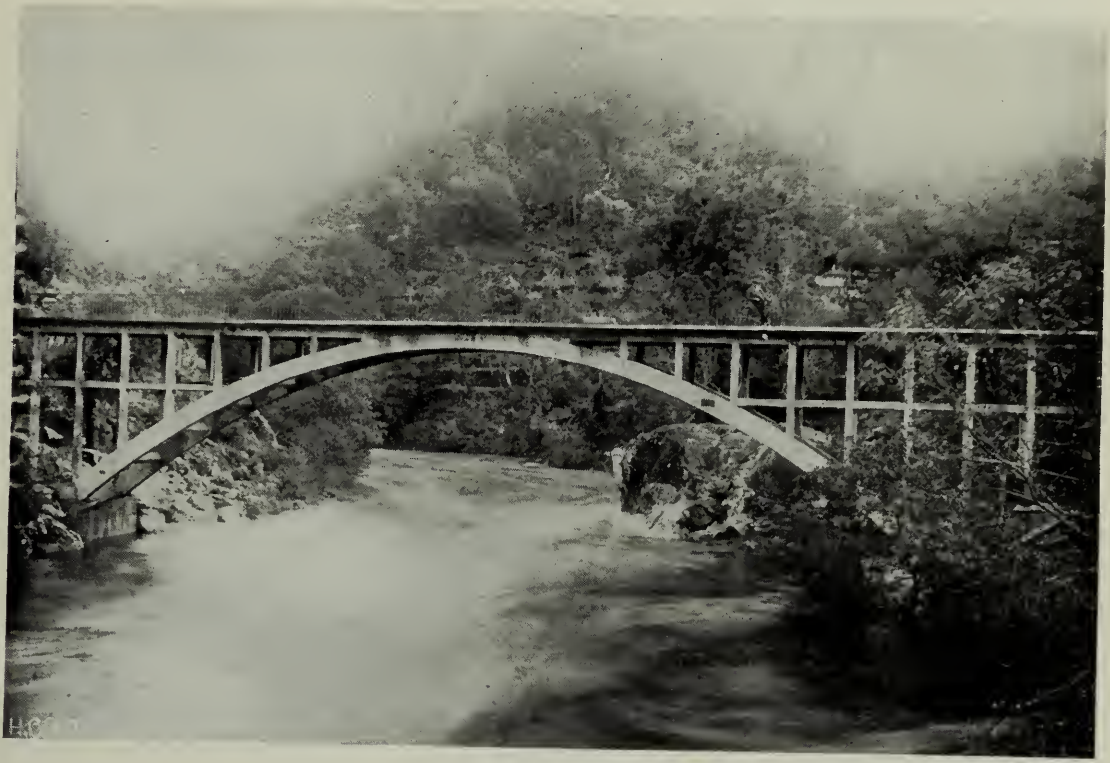


Fig. 2. Reinforced Concrete Bridge at Oliveira de Prades, Portugal.

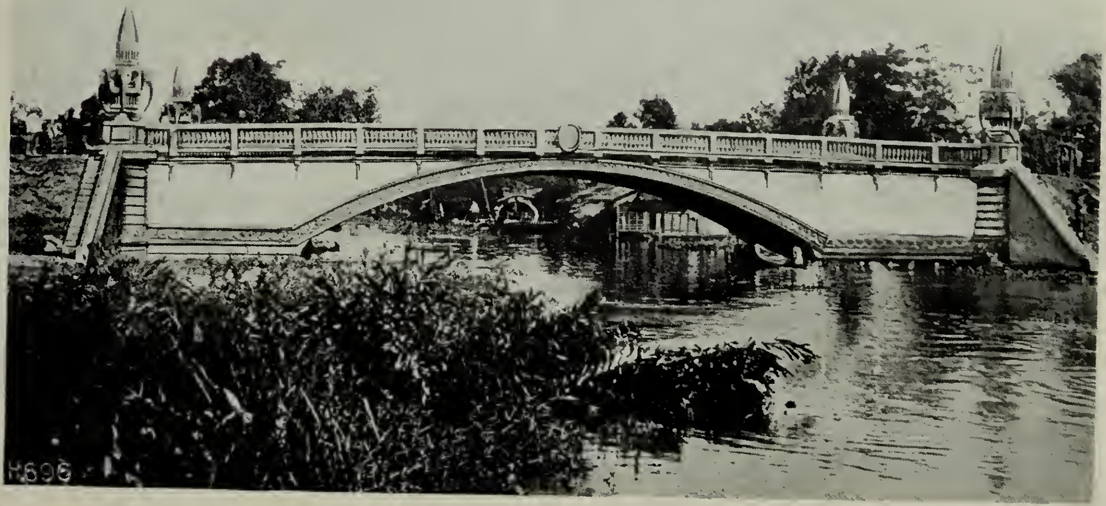


Fig. 3. A Reinforced Concrete Bridge in Siam.

Reinforced concrete was undoubtedly an ideal material to use under such conditions, and the authorities recognised this, the result being that this material was chosen. The total length of the bridge is 44m., and since its erection it has had to withstand a flood more terrible than anything remembered in the district, the arches of the bridge being entirely submerged. Not only so, but trees were carried down the river, and collided with great force against the bridge. What was the result of this unusual test of the structure? It resisted the attack admirably, and not a crack presented itself, although a bridge of iron, wood, or stone would have been swept away almost immediately. This bridge is also interesting, because it was constructed (apart from carpenters and blacksmiths) by nine robust women.

(*c*) ***Reinforced Concrete and the Bridges of Siam.***—Two of these bridges are shown in *Figs.* 3 and 4.

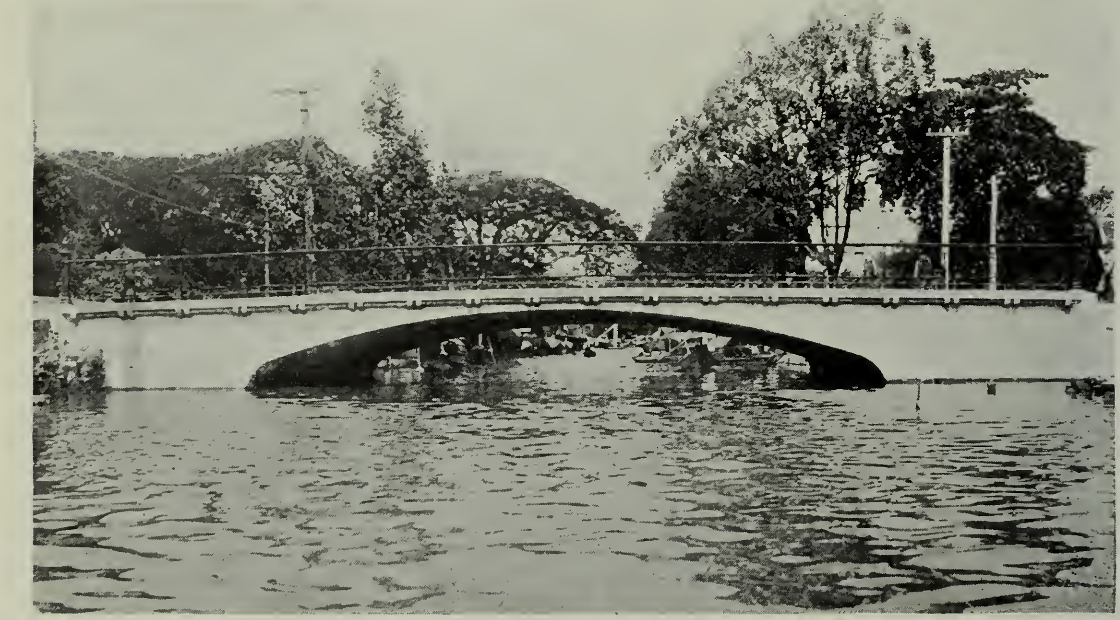


Fig. 4. A Reinforced Concrete Bridge in Siam.

After deciding to construct a palace worthy of his capital, King Chu-la-long-Korn chose a site at a spot known by the name of Dusy-Park, situated in the broad valley of Ménam, which runs some hundred metres from there. The site was excellent, but the ground was little suited for the erection of heavy buildings; in fact, it was scarcely able to support a weight of 600 grams per cm^2. The engineers at first endeavoured to construct a substructure consisting of masonry arches, but they subsequently, after spending a large amount of money, abandoned this idea, as they found the scheme was unworkable.

The work was then deferred indefinitely, until after several years the project was again discussed, and it was decided to make inquiries in Europe regarding the construction of foundations of heavy buildings on treacherous soils.

The engineers to the Siamese Government adopted the process of mechanical compression of the soil. The arches referred to were bound together and strengthened by reinforced concrete soles.

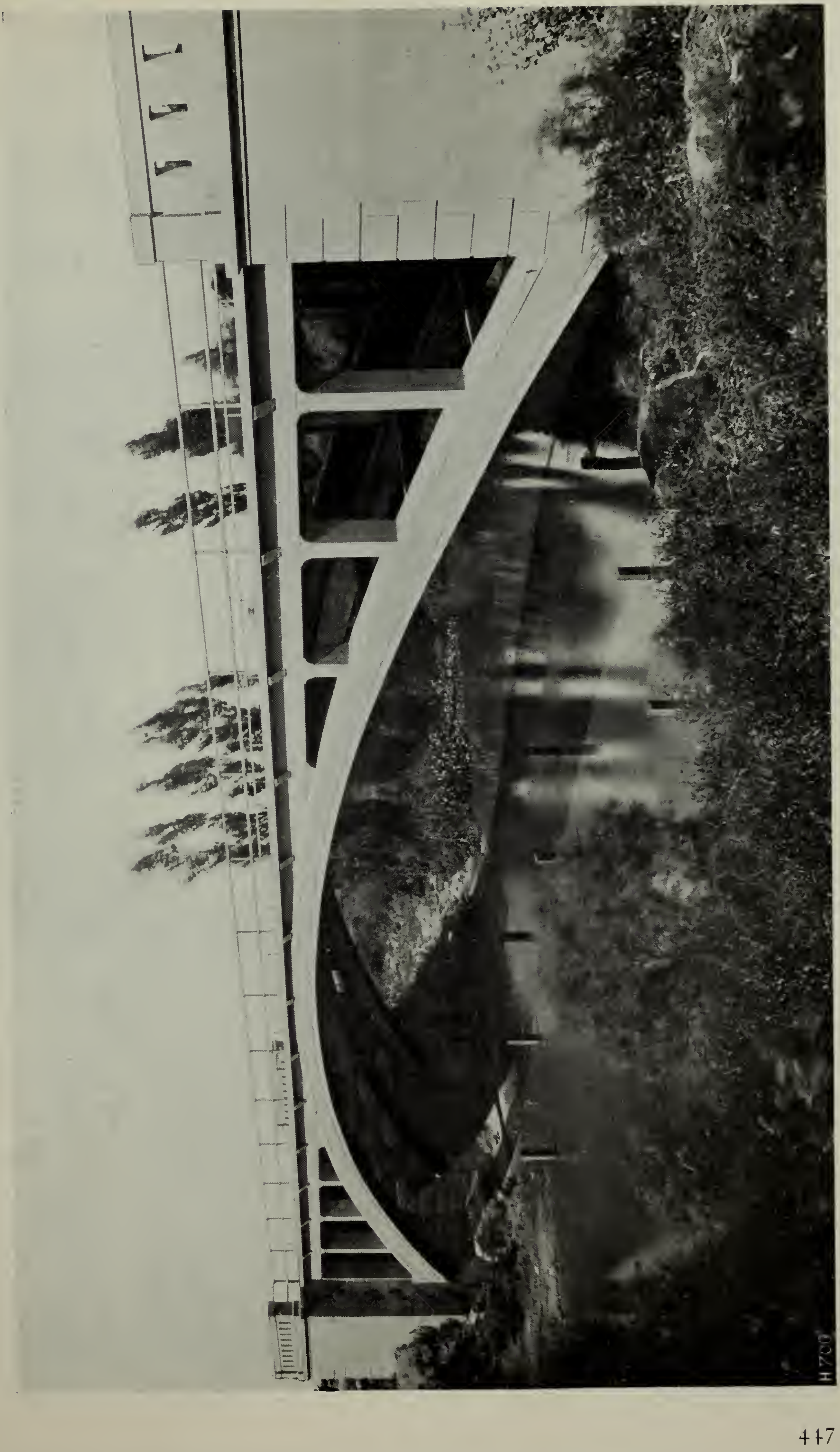


Fig. 5. Reinforced Concrete Bridge over the Arroyo Canelon Chico, Uruguay.

This was the first time that this material had been used in that distant country.

The floors of the palace at Bangkok and also the central cupola were constructed in reinforced concrete.

At the same time several bridges of various spans were erected in this material by the Siamese administration. Illustrations of two of these are here given. *Fig.* 3 illustrates a bridge situate at 3 kilometres from Bangkok over the Klong-Mahanak. The foundations and abutments are of reinforced concrete, and form hollow caissons in order to distribute the weight over a large area, and with a view of limiting the co-efficient of work of the soil to 700 grams per cm^2.

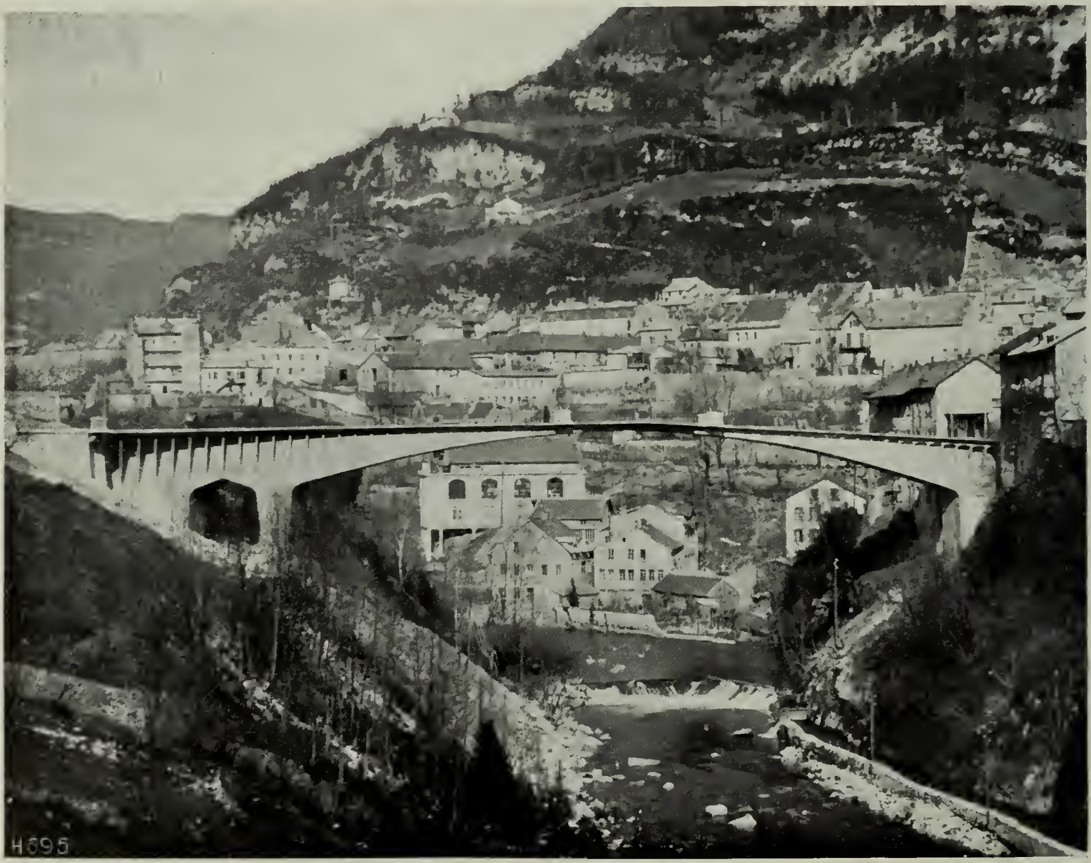


FIG. 6. REINFORCED CONCRETE BRIDGE OVER THE BIENNE AT SAINTE CLAUDE.

The work took only three months to execute. The bridge is artistic in design, the Siamese being excellent decorators, and the king expressing a desire that this structure should be very ornamental.

Fig. 4 represents another reinforced concrete bridge erected for the Siamese Government. It is similar to the one just described, and was also constructed on the Hennebique system. It spans the same river. It is situate 2 kilometres further up the river. The foundations are on timber piles. The "base" of the abutments and the foundations are preserved from corrosion of the waters by masques of reinforced concrete descending to 3 metres, and downwards below the lowest tide.

This bridge was constructed entirely by Siamese labour, while that illustrated in *Fig.* 3 was built chiefly by European workmen (French).

The former took four months to complete, and in connection with it 800 piles were driven.

It might be mentioned that the administration are pleased with these structures, and the King of Siam has shown a great interest in their construction.

(*d*) ***Bridge over the Arroyo Canelon Chico (Uruguay).***—Another bridge of considerable importance will now be referred to. This was built in Uruguay in 1909, the contractors being Messrs. Monteverde & Fabini. The bridge spans the Arroyo Canelon Chico, and consists of a single arch of 35 metres span. It is 7·5 metres in width, and is light and artistic in appearance. It is illustrated in *Fig.* 5.

The abutments rest on piled foundations, and are of reinforced concrete. The work was commenced in January, 1908, and completed in August, 1909.

The bridge was designed by Juan P. Fabini, and executed under the supervision of the engineers, Luis P. Ponce and Francisco Iglesias Hijes, officers of the State.

The total length of the bridge is 47 metres.

(*e*) ***Bridge over the Bienne at Sainte Claude (Jura).***—This bridge, shown in *Fig.* 6, is also built entirely of reinforced concrete, and represents a fine piece of engineering work. It crosses the Bienne at 35 metres height by an arch of 65·7 metres span, the rise of the arch being only 5·38 metres.

The test of 70,000 kilos on the footpaths and 80,000 on the roadway showed a deflection of only 17 mm., which immediately disappeared upon the removal of the load.

The total length of the bridge is 96 metres. A brief history and description of the bridge is as follows: On the right bank of the River Bienne, near to the railway station, is situated the only land on which this industrial town can be developed. Until the bridge here described was erected there was no direct connection between this land and the town itself. St. Claude possessed two bridges, one situated at the northern and the other at the southern end of the town. These bridges were notoriously insufficient, and for a long time the authorities had under consideration the erection of a central bridge. The public body moved, however, so slowly that private enterprise eventually had to undertake the project; and so the central bridge was built (independent of any financial support by the public authority), thanks largely to the enterprise of M. Brizon, President of the Tribunal of Commerce of Lyon, who presides over the Council of Administration of the Society of "New Bridges and Districts of St. Claude." This bridge, as stated, is of reinforced concrete on the Hennebique system. The arch is 50 centimetres in thickness, transverse walls are built every 2 metres apart, and the whole structure forms a monolith.

The lightness of this structure shows the advantage of using reinforced concrete from the point of view of the saving of material.

The bridge has a width only of 4 metres at the centre. The roadway and footpaths, however, have a width at this point of 6·20 metres, while above the abutments this width is increased to 11·40 metres. It is doubtful if a bridge of this shape could have been constructed with anything like economy in any other material than reinforced concrete.

The projecting footpaths and roadway are carried by reinforced concrete brackets of extremely simple and light design, and these have a very pleasing effect from an architectural point of view.

The bridge is on the skew, the abutments forming between themselves an angle of 21°. The springing of the arch on the right bank is 1·35 metre above that of the left bank. The plans were prepared and the work executed in 13 months. The bridge was completed in August, 1909.

It might be mentioned that the winter at St. Claude is particularly severe, and it is no unusual thing for the temperature to drop to 20° below zero.

The bridge was tested upon completion, and in every way satisfied the engineers to the authorities.

(*f*) ***Bridge at Mescla (Alpes-Maritimes).***—This bridge, shown in *Fig.* 7, has a free span of 60 metres between the abutments.

The work took 95 days, and the engineer in charge was M. Arnaud, Chief Engineer des Ponts et Chaussées.

The bridge will take a moving load of 105 tons at a speed of 30 kilometres an hour.

Conclusion.—The author would repeat what he has expressed so often—that, in his opinion, reinforced concrete is an ideal material to use in bridge construction.

He would, in conclusion, express his indebtedness to Monsieur Hennebique, of Paris, for kindly furnishing him with so much information regarding these interesting structures, and to Mr. J. Matthews, the postmaster of Deal, for kindly translating this information.

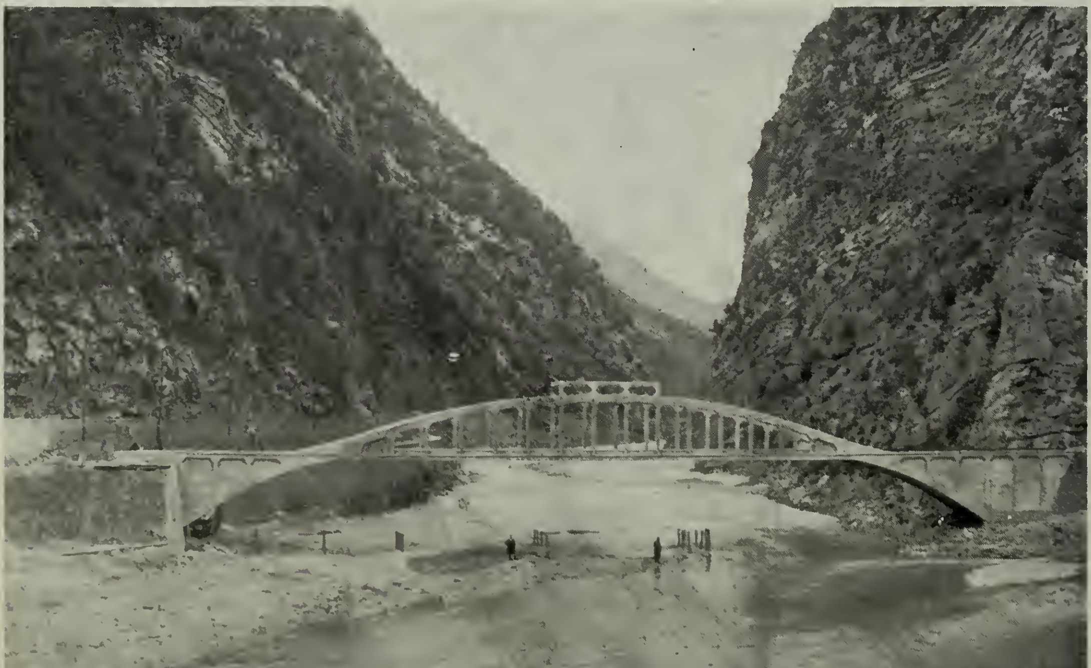


Fig. 7. Reinforced Concrete Bridge at Mescla, Alpes-Maritimes.

RAPID RE-INFORCED CONCRETE CONSTRUCTION ON THE MICHELIN TYRE FACTORY AT FULHAM

It affords us considerable pleasure to illustrate a factory built in London which has been erected very rapidly in reinforced concrete, and which serves to prove that reinforced concrete work, if properly organised, in no way delays the construction of a building of this description.—ED.

THE above building is erected on an island site with a floor space of about 100,000 ft., and bounded on all sides by roads: Fulham Road, Leader Street, Sloane Avenue and Lucan Place.

The basement contains all the machinery, including the engine repair shops, pneumatic compressor, electric light, heating and ventilating, etc., etc.

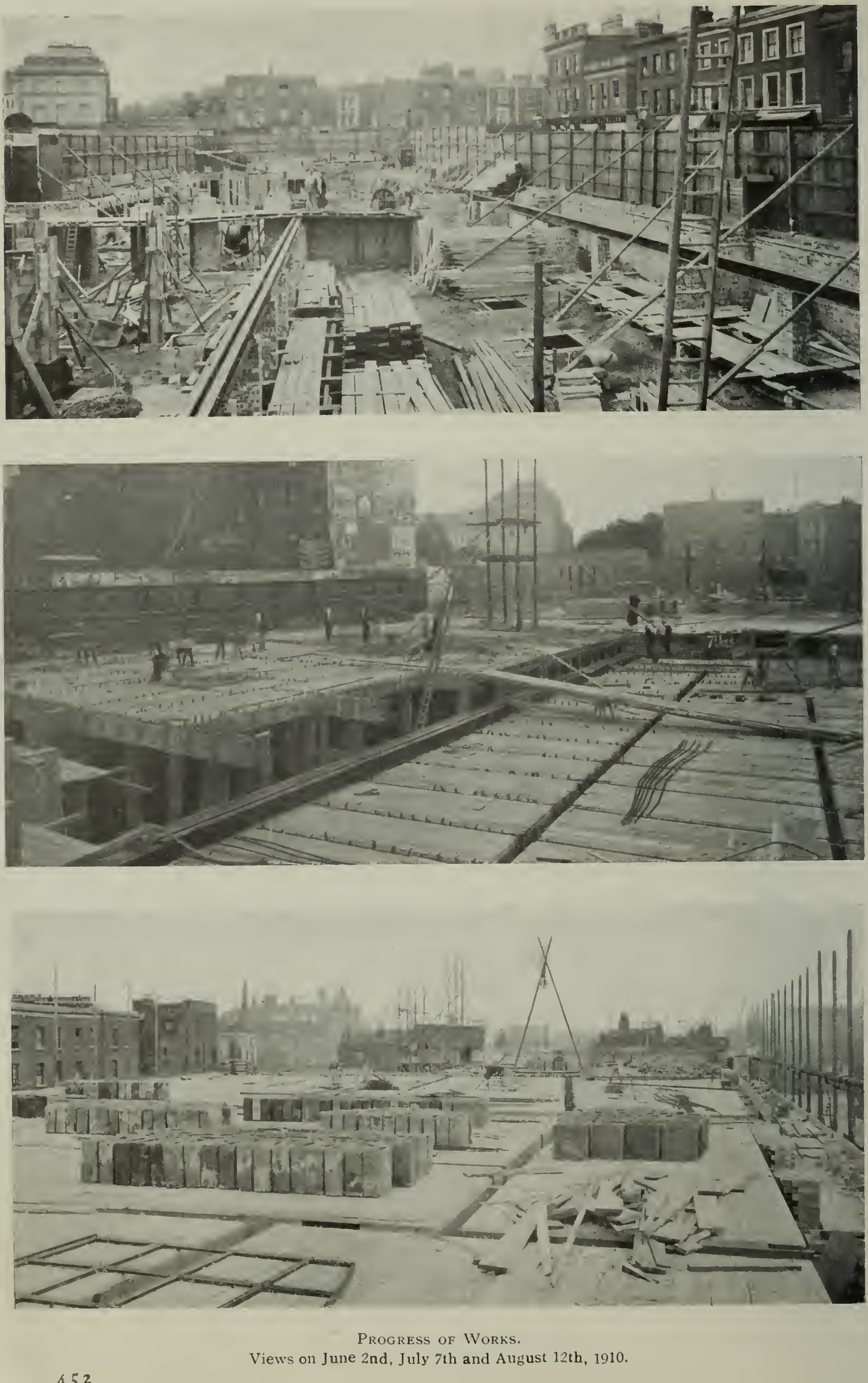
The ground floor has a main entrance in Fulham Road so arranged that cars can drive through one gate into the building to be fitted with tyres and leave by another gate. On this floor is situated the sale room, touring office, tyre store, loading stages (of which there are eight, so that eight railway vans can be dealt with at one time) and at the back is a garage for accommodating thirty or forty cars.

The upper part of this building, approached by two staircases and two lifts, accommodates the office staff of some 300, the directors' room, board-room, etc.

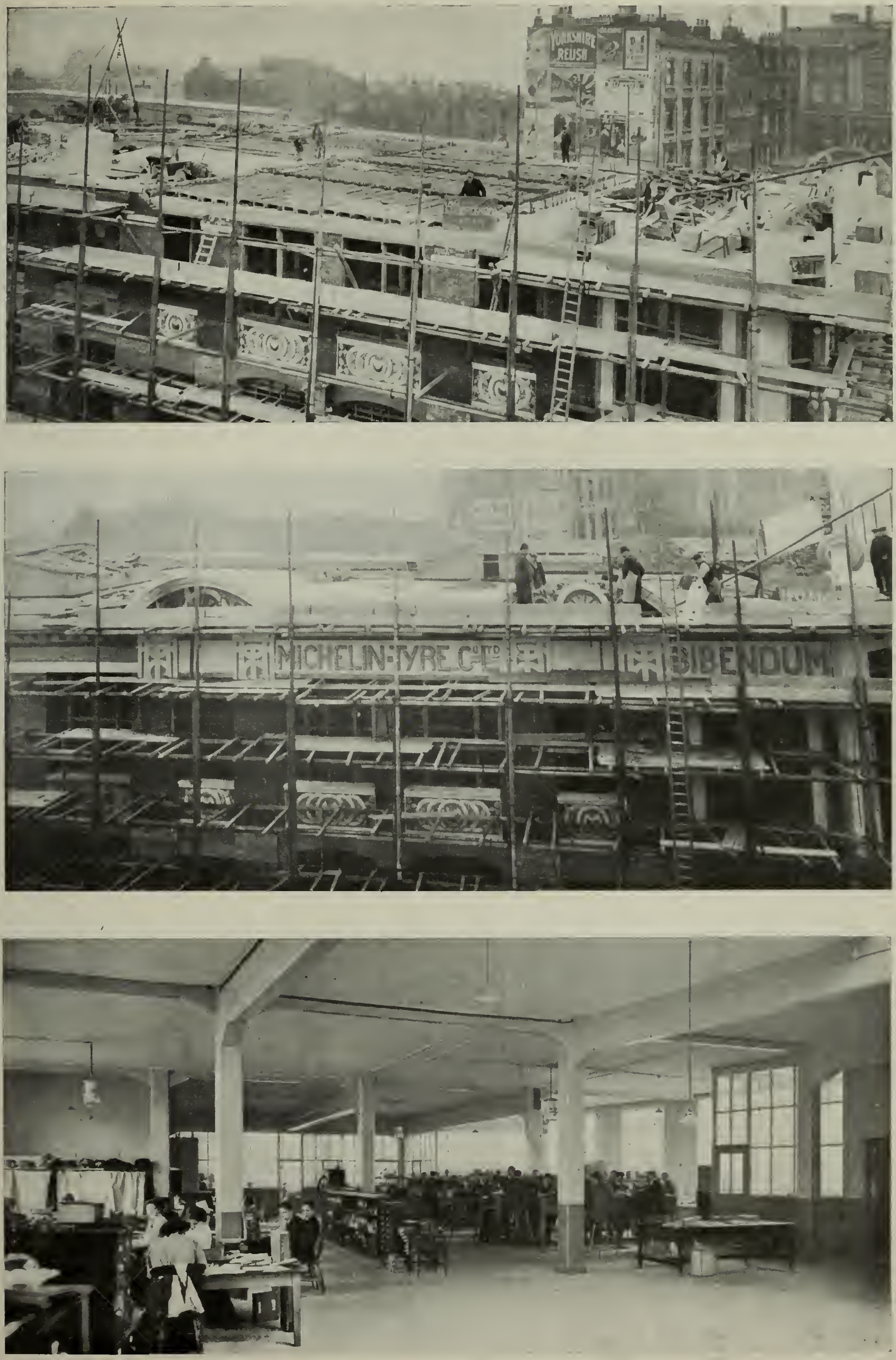
The building was designed by Mr. Espinesse, the reinforced concrete work was by Messrs. Mouchel & Partners, and the whole of the work was carried out by Messrs. W. J. Fryer & Co., of Bravington Works, Paddington.

It is often said that reinforced concrete work takes much longer than ordinary brick work and steel construction; this is quite a mistaken idea, as this huge building was erected in the record time of five months, and speaks well for the organising power of the engineers and their contractors.

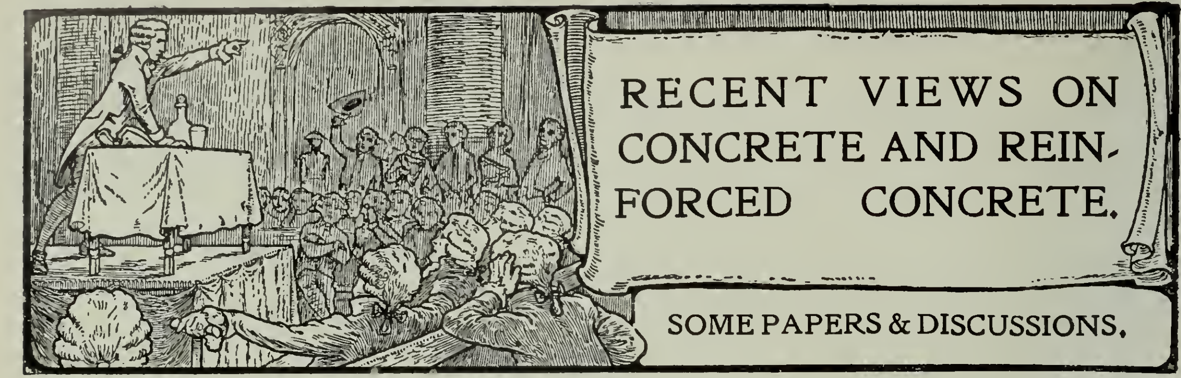
It is interesting to note that some few years back Messrs. Fryer anticipated that there would come a time very shortly when in order to meet competition it would be necessary for manufacturers to rebuild their factories, and they have specialised somewhat in this class of work, as not only do they erect the building, but also have a large staff of engineers to carry out the equipment of the plant, electrical or otherwise, which naturally enables them to bring the different sections of the work much more rapidly to completion.



Progress of Works.
Views on June 2nd, July 7th and August 12th, 1910.



Progress of Works.
Views on September 14th, October 14th and December 15th, 1910



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

IRISH ROAD CONGRESS.

THE PLACE OF REINFORCED CONCRETE IN MODERN ROAD CONSTRUCTION.

By Professor C. W. L. ALEXANDER, M.E., Assoc.M.Inst.C.E., University College, Cork.

We give below an extract of a short paper read by Professor C. W. Alexander at the recent meeting of the Irish Road Congress.

In a country like Ireland, where distances and mileage are large in proportion to the resources and population, it is necessary, in designing, to keep down cost to an extent that is not so essential in England. In other words, if a scheme is considered necessary for the public convenience, the money required can generally be secured in England, whereas in Ireland a sum is fixed for the work by some considerations, independent of the engineering difficulties of the scheme, and unless it can be executed for this amount, it is shelved entirely.

Modern traffic, by reason of its increased weight and speed, has imposed the necessity of strengthening the foundations and crust of main roads. It will further be necessary to reconstruct a large number of small road bridges over streams and other similar obstacles. It is the object of the writer to draw attention to the fact that reinforced concrete is not only the best material for this work, but that it is also the most economical and most convenient for the conditions prevailing in this country.

Most of these small bridges are constructed of masonry of varying quality. These are, in a large proportion of instances, unequal to the task of carrying heavy rolling loads, through—(1) Defective foundations and yielding abutments; (2) Open joints and defective mortar; (3) bad construction and shape.

In order to decide upon the best kind of bridge to replace these old masonry structures, one has to consider the limiting conditions, the chief of which are:

1. The span is short, say, from 5 ft. to 20 ft., with an average of 10 ft.
2. The rise is limited, with the necessity of providing as large a waterway as possible, with a comparatively small space between road level and the water.
3. The foundations are very often bad, and always uncertain.
4. The materials have to be got to the spot by cart, causing expense and delay where stations are remote, and much stuff has to be procured, and labour is always more or less unskilled.
5. The same sort of culvert or bridge may have to be reproduced many times over on one main road, and dozens of times in one surveyor's area.

For a span of the length named, steel is out of the question, so that masonry or brick is the only alternative to plain or reinforced concrete.

The objections to masonry are:

1. It must be built as an arch, and engineers need not be told that, where solid ground is wanting, it is not possible to construct this without the certainty of having cracks.
2. Masonry is slow, and the construction causes unnecessary interruption to traffic.
3. It is extremely costly both in carting and in labour.
4. It does not provide waterway in proportion to the weight and cost of the bridge.

Many of these objections apply to brickwork, which has the further disadvantage that it is not easy to get a hard, durable brick on sites in outlying districts at reasonable cost.

It should be noted that centering is necessary for both masonry and brickwork, as well as for concrete. The latter should be considered first in its plain form, and, secondly, when strengthened with steel.

Advantages of Reinforced Concrete.—The special merits of reinforced concrete are :

1. It need not be built as an arch, but can be made in flat beams, with an overlying slab, and for the spans mentioned is by far the most economical structure, because—

(*a*) The reactions are all vertical, and the pressure on the abutments may be so distributed, by making a simple mattress impost of concrete and bars, that settlement is improbable, and cannot in any case do any harm.

(*b*) The centering is all made of straight, square timber, can be constructed by any country carpenter, is easily fixed, and can be used over and over again.

(*c*) The waterway is much greater, for the same conditions, than the arch.

2. The amount of materials is a minimum, and the steel is of simple bars, easily procured, and costs comparatively little.

These facts establish the claim of reinforced concrete to the consideration of county surveyors. Engineers have hitherto fought shy of it, partly because of the great novelty of the combination of the two materials and of the uncertainty as to the life of the steel, and partly because of the fact that, from the way it was exploited by firms holding patent rights or having patent bars to sell, they were led to believe that there was some awful mystery in the design of structures in reinforced concrete.

As a matter of fact, nothing is simpler than the calculations for beam and girder work of this kind. The real difficulties—and they are of a kind that all engineers have to cope with every day—are—

1. The necessity of securing that the cement is absolutely right and that the gravel and sand are in proper proportion and suitably graded. Systematic and constant testing is essentia for this.
2. Strict supervision from start to finish must be given.
3. The centres should not be struck nor loads carried until the concrete is thoroughly well set.
4. A fairly rich concrete, not less than 6 to 1, and preferably richer, should be employed, and the steel should always have a good covering, if possible 1½ in. at least. Of course, with a 4 to 1 concrete a less covering is permissible, but economy of this kind is not advisable.

So much has been written in the last few years on reinforced concrete that unreasonable expectations have been raised about it in some quarters, while in others, doubts exist as to whether it will stand the test of time. Here is a field in which its initial cost is at least as low as anything else, and its failure is no more likely than that of poor masonry, at the very worst. The writer, therefore, hopes soon to see reinforced concrete employed for many purposes by the road engineers in a manner which will tend to general efficiency and economy.

UNIVERSITY OF TORONTO ENGINEERING SOCIETY.

INSPECTION OF CONCRETE.

E. A. JAMES, A.M.Can.Soc.C.E.

The following is an abstract of a paper which appeared in the Transactions of the University of Toronto Engineering Society.

In concrete work, as in other classes of construction, good design and good materials are necessary, and, granting that we have good design and good materials, a class of well-skilled workmen should produce a finished material of a high order. Concrete, however, has suffered more than any other building material because of inferior workmen, and this has been brought about largely by those interested in the early days in the sale of cement, who claimed as one of the chief reasons why it should be largely used was the cheapness of placing, because it did not require skilled labourers. Fortunately, we do not hear so much of the claim as formerly, for it is well recognised that workmen can, with the same ingredients, produce various grades of concrete.

Although among the first of the modern concrete structures many were well and substantially made, yet there were a number of serious failures, and because the engineers themselves were not any too familiar with concrete construction, and owing to the fact that most of the workers in concrete were men imperfectly skilled, a system of careful inspection was inaugurated.

While the necessity of inspection depends to a certain extent upon the nature of the material and the production, it is always a question of just when and where and to what extent it pays to inspect. In concrete work inspection must be made of the component parts; the sand, the gravel, the cement, and the water must be examined, as well as the concrete, while it is being mixed and poured.

System of Inspection.—The scope and possibilities of a system of inspection enlarges greatly with specialisation.

Inspection should be planned to accomplish at least expense the best results, which may be numerated something as follows :

1. To prevent loss or defects by accidents or delays.
2. To prevent loss of time and material on work already beyond repair.
3. To prevent the necessity of replacing defective work.
4. To prevent decrease in quality because of the demand for increase in quantity.
5. To point out imperfections in alignment, methods, and material.
6. To record proper allowances for unavoidable extras.
7. To draw the attention of the superintendent to workmen who must be better instructed or trained.
8. To stimulate goodwill through fairness in fixing responsibilities.

Inspection organised to cover any one or all of these purposes will be similar in personality, varying only with the degree of perfection required.

Before it can be determined just when and where it pays to inspect, the following conditions must be satisfied :

1. Responsibility must be fixed with certainty.
2. The inspection must not cause unnecessary friction.
3. The inspector must have to do with quality only, not design.
4. The responsibility for defective work must be placed upon the workman as well as upon the inspector.

Responsibility must be fixed with certainty.—As inspection has for its purpose the pointing out of the defects, it is necessary for the inspector to be able to locate the cause of the defect. One of the most foolish things that can be done is attaching blame to the wrong person, and unless it is possible to discover immediately just when and where the cause of the defect lies, the fixing of responsibility is very difficult. It is therefore necessary to have the material on the ground in sufficient time for thorough inspection before it is mixed, for even after the inspector has detected the defect, the responsibility is not necessarily fixed. The error may be due to wrong specification, poor material, defective measurement, defective mixing, or even unsuitable weather conditions. It is therefore necessary that instructions and specifications must be in writing.

Inspection must not Cause Unnecessary Friction.—No system of inspection which would simply complain of defects, without attempting to trace the cause or to assist in the improving of conditions, will be of any assistance. It certainly would not tend to happy relations between contractor and engineer. So it becomes necessary, if full benefits are to be derived from rigid inspection, not only to point out the defects, but the inspector should be in a position to trace the cause and to suggest a remedy. Defective work must be detected as soon as possible, so that the conditions under which the work was done may be fresh in the workman's mind, and the responsibility with certainty attached to him when the defect is through careless workmanship.

The Inspector must Examine Quality only, not Design.—To point out defects will not necessarily stop the repetition, and, although it may be the duty of the inspector to trace the cause, fix the responsibility, and suggest the remedy, the inspector must not have to do with applying the remedy or of interfering with the workmen.

When the inspector has reported defects in material or workmanship to the engineer and contractor, or their representatives, he must content himself with awaiting the corrections through the proper officials, although it should be within his power to stop or reject the work until there is an opportunity for investigation, and to take upon himself these responsibilities he must have knowledge equal to that of the superintendent of the work.

Responsibility for Defective Work placed upon the Workman as well as upon the Inspector.—While we have stated that the inspector should not interfere with the workman, yet the knowledge that he is present will have a disciplinarian effect, and will prevent the sacrifice of quality for quantity. Inspecting alone will not reduce bad workmanship to a minimum, but the workman must be supplied with proper tools, proper instructions, and must be trained in his work and held responsible for the quality of his work. He must be trained to inspect his own work.

Plan of Inspection.—There are many plans of inspection, any of which may get good results, and all of which may fail in securing good results. Inspection depends more upon the inspector than upon the method. You may have inspection by central bureaus which retain men who are experts in their line of work, who report first to their bureaus or to the engineer in charge of the work, as may be arranged. You may have inspection by your own local staff or foreman, or you may require such guarantee that inspection at the end of one or two year periods will be all that is necessary. The plan of inspection to be adopted will necessarily depend on the character of work being carried out.

The Duties of the Inspector.—It should be the duty of the inspector to see that all forms are erected on the lines laid down by the engineer, that these forms are stiff and well braced, and that all material and workmanship are in accordance with specifications. He should look after the removal of forms and see that the concrete is not injured in the removal.

Apart from concrete walks, form work is the most difficult to get properly placed, and it is much easier to develop a good inspector out of a good carpenter than out of a good concrete worker.

If the work is to be done at night under artificial light, it will be necessary to increase the staff of inspectors, for concrete that can be detected in the daytime by colour will not show a lack of proper mixing of materials under artificial light; in fact, where high-class work is required, or in finishing surfaces, as a rule it is better not done at night at all.

The cost of inspection is variable, being in some cases as low as 1 per cent. of the total cost, and as high as 2½ per cent.

CANADIAN CEMENT AND CONCRETE ASSOCIATION.

SOME EXPERIMENTS WITH CEMENT TILES.

Paper by By PROF. W. H. DAY.

(Ontario Agricultural College, Guelph, Canada.)

Below we give an abstract of a paper which was read last year at the meeting of the Canadian Cement and Concrete Association by Professor W. H. Day.

SINCE the Ontario Agricultural College began College Extension work on the subject of farm drainage, some five years ago, there have been numerous enquiries for information on the subject of cement tiles. People usually wanted to know two things: first, whether the cement tile could be made cheaper than the clay tile; and, secondly, whether they would be durable.

For use in our experiments on the cost of manufacture the London Concrete Machinery Company furnished us with one of their two-piece cement tile machines, since taken off the market. And the experimentation was undertaken by Mr. A. M. Shaw, one of our students, who had had considerable experience in cement work with his father, the late Mr. Robert Shaw, of Niagara Falls, Ontario, who for several years did much of the road contracting in his locality.

While writing the report of these experiments in the latter part of the year we learned of the controversy over the durability of cement drain tiles. We decided to conduct some tests in order to learn for ourselves something about the solubility of cement, and to deduct from the information thus obtained some idea of the probable durability of cement tiles. These experiments were begun in February, 1909, and have been continued until the present.

THE COST OF MAKING CEMENT TILES BY HAND.

The tiles made by the London two-piece machine were hexagonal on the outside, being about $\frac{3}{4}$ of an in. thick in the thinnest part, and considerably thicker at the corners. Mr. Shaw found that, mixing his own material, he could make a shade over 500 complete 3 in. tiles in a day when everything was once in order. The material had to be mixed quite dry in order that the moulds might clean—so dry, indeed, that it was impossible to tamp it close enough to make a compact tile. By oiling the moulds it was found that the material might be mixed much wetter, but still not wet enough to make what we consider a good tile. We also thought that considerably more material was used in the tile than would be necessary for a round tile; and, besides, the amount of handling required for two-piece tiles was double that for one-piece. These features led us to doubt if this type of machine would ever be popular with the farmers. On consultation with the company we found that they had arrived at the same conclusions, and that they were withdrawing the machine from the market. These circumstances at first led us to think that the work done on this phase of the problem was of little practical value, and we discouraged the extensive publication of the result, although we placed them in our annual report, just as a matter of record. On second thought, however, we have changed our opinion somewhat, for the following reason: The rate of manufacture determined must represent fairly well what might be expected with a round-tile machine of similar dimensions—the round tile would be slower to tamp, but there would be only half as many pieces to handle. As a matter of fact, we have since learned of a hand machine for round tiles, recently invented, on which one man can make about 500 tiles a day, thus establishing that the rate of manufacture determined in our experiment is in all probability a fairly representative one.

We found that 6 cu. ft. of sand and one bag of cement (approximately a cu. ft.) would make 78 complete 3-in. tiles. But a round tile, $\frac{1}{2}$ in. thick, requires only 55 per cent. as much as the one made on the London two-piece machine, hence the material mentioned above would make $\frac{100}{55} \times 78$, or 142 tiles, providing they were tamped to the same compactness. As they could be made wetter they would likely be somewhat compact. This, however, would be counterbalanced by the use of another half-bag of cement, making the proportions 4 of sand to 1 of cement (6 to 1 is too poor for really strong tile), so that we may fairly assume from our figures that from 6 cu. ft. of sand and $1\frac{1}{2}$ bags of cement there can be made 142 3-in. tiles—say 140 in round numbers. This gives us a means of arriving at an estimate of the cost of making 3-in. tiles, $\frac{1}{2}$ in. thick, by hand, when the price of material is known. In Guelph we pay $1 (4s.) a yard for sand, and $1·90 for cement. At these prices—

Total cost of 500 tiles	$5·32 (£1 1s. 3d.)
Total cost of 1,000 tiles	$10·64 (£2 2s. 6d.)

The prices used in estimate may be high in some localities, but, knowing that 6 ft. of sand and $1\frac{1}{2}$ bags of cement will make 140 tiles, and that a good man can make about 500 tiles a day on certain types of machine, the cost of manufacture may be figured out to suit cost of materials in various localities.

SOLUBILITY TESTS.

Next we come to the solubility tests.

EXPERIMENT I. Sample.—A piece of cement tile weighing 43·256 grains after being dried to constant weight at 215° F. This tile was made by the "dry process" in April, 1908, in proportions 6 of sand to 1 of cement. For a few days after being made it was watered daily, and then it was submerged in water for a period of six weeks, after which it was removed to a storage cellar, where it remained until solubility experiments began. Tile quite porous.

Treatment. — After the small piece had been dried to constant weight it was placed in distilled water for four days, then removed, dried, weighed, and again placed in fresh distilled water. As convenience allowed it was dried, again weighed, and once more placed in fresh distilled water. This was repeated 16 times, the total period of solution being 143 days and the total loss in that time was ·113 grains. The total cement in the sample was 7·1794 grains, hence at this rate the cement would all dissolve in 27·7 years.

The experiment was next performed with water from the artesian wells at the College. This water is high in total solids, about 480 parts per million, made up chiefly of bicarbonate of calcium, bicarbonate of magnesium, or the compound bicarbonate of calcium and magnesium. There is also a small amount of chlorine in it. The sample was tested five times in this water, the total period of solution being 47 days and the total loss in weight ·090 grains. At this rate it would take only 10 years to dissolve all the cement in the sample.

EXPERIMENT II. ***Sample.***—A piece of tile, proportion 6 to 1, made on London two-piece machine, May, 1908, watered daily for a week after making, stood in cellar till November, 1909, mixed much wetter than sample used in experiment I., so wet that the moulds would not clean well. Dry weight 43·213 grains.

Treatment. — Same as sample in experiment I., only the number of tests in distilled water numbered eight instead of 16, the total period in the water being 73 days. During the period the sample lost ·025 grains, at which rate it would take 57·4 years to dissolve all the cement in it. When put in the well water the loss in 42 days was ·090 grains, which rate would use up all the cement in 10·3 years.

EXPERIMENT III. ***Sample.***—A piece of wet-mixed tile, made the same time as No. 2, and watered and stored in the same way. Dry weight 36·2795 grains.

Treatment. — Distilled water for 73 days, well water for 47 days.

Result. — This sample lost only slightly in distilled water, and gained ·0333 grains in well water. At this rate it would last for ever.

EXPERIMENT IV. ***Sample.***—A piece of tile, proportions 4 of sand to 1 of cement, made by George Holden of St. Mary's, on the London Automatic cement tile machine. Watered daily for a week after being made, and then stored in our laboratory until October, 1909. Dry weight 20·4792 grains.

Treatment. — Same as in 2 and 3.

Result. —Loss in distilled water in 73 days = ·0387 grains. At this rate the sample would last 26·5 years.

In well water the total loss was ·130 grains in 47 days, at which rate the sample would last only 5·1 years.

EXPERIMENT V. ***Sample.***—A piece of tile, proportions 4 of sand to 1 of cement, made by same maker as No. 4, cured and stored in the same way. Dry weight 35·781 grains.

Treatment.—Same as others.

Result. — In 73 days in distilled water the loss was ·0175 grains, at which rate the sample would last 102·2 years. In 47 days in well water the sample gained ·0165 grains in weight, and thus would never disintegrate.

In estimating the time that samples would last it has been assumed that they would be subject to solution 365 days in the year, and that the rate of solution would be uniform. The first of these conditions certainly would not hold in practice. During a large portion of the year—possibly half—tiles are dry and not subject to solution, and, consequently, would last twice as long as the periods mentioned, provided the rate of solution during the other half of the year was constant.

We had hoped to establish something definite as to the rate of solution, but we have failed to do so yet. The rate of solution seems to fluctuate with some factor other than time, probably temperature.

Just when our curve for rate of solution would reach a constant for two or three readings, this variation would occur and prevent conclusions. In all samples the rate of solution in distilled water appeared to fall off, slowly in most cases, but very rapidly in a few, especially in the case of the clay tile. Then, placed in the well water, the samples all behaved irregularly at first, giving either large losses or else large gains, and these losses or gains fell off rapidly.

Three other experiments were performed, which probably come nearer natural conditions than the previous experiments do. Three half-tiles were placed in running well water on May 6th, 1909, where they have been ever since. At the end of six months they were dried, weighed, and replaced in the water. Then last week they were dried and weighed again. The results are as follows:

EXPERIMENT VII. ***Sample.***—A half tile, proportion 6 to 1, made on London two-piece machine, dry process. May, 1908, watered for a week, stored in cellar. Dry weight 1,797·5 grains.

Treatment. — In running well water for 10½ months, weighed at 6 months and at 10½ months.

Result.—Tile gained in weight each time. Total gain 3·4 grains.

EXPERIMENT VIII. Sample.—Same as in 7. Dry weight 1,910·25 grains.

Treatment.—Same as 7.

Result.—No change in weight in first 6 months, a gain of 4·05 grains in next 4½ months.

These two samples would never disintegrate at this rate.

EXPERIMENT IX. Sample.—A half tile, proportion 6 to 1, made on London two-piece machine, made very wet, so much so indeed that tile would not hold shape, and mould would not clean. Allowed to dry, getting a few showers of rain, and then stored in cellar. Dry weight 2,001·0 grains.

Treatment.—Same as in 7 and 8.

Result. — Tile lost 1·90 grains first 5 months and 2·70 grains next 4½ months. At this rate the sample would last 63·4 years.

It is worthy of note with regard to these three samples that those made by the dry process, and therefore very porous, were the ones to lose.

The behaviour of these three large samples would seem to indicate that cement tiles in the soil, subject to running water of low temperature, are likely to last much longer than would be indicated by experiments with smaller samples at room temperature.

It is our intention to continue the work on the solubility, as we realize there is much yet to be learned about it.

POROSITY.

With regard to the porosity, we find that it varies with the proportion of cement, with kind of sand used, and also with the method of making. The more cement used, the finer the sand, or the wetter the mixture, the less porous the tile. But even the most compact ones tested were much more porous than clay tiles.

NEW BOOKS

AT HOME AND ABROAD.

A short summar of some of the leading books which have appeared during the last few months.

A Specification for Reinforced Concrete Work. By A. Alban H. Scott and Percival M. Fraser.

Published by Witherby & Co., Newman Court, Cornhill, E.C. Fcap., 30 pages. 3/6 net.

Several standard specifications for reinforced concrete work are to be found in the publications issued by specialist firms, and the Report of the Joint Committee on Reinforced Concrete appointed by the Royal Institute of British Architects, and the Report of the American Joint Committee on Concrete and Reinforced Concrete, are both drafted somewhat on the lines of a specification. Certain American publications also give standard specifications for reinforced concrete work. Messrs. Scott and Fraser are, however, apparently the first professional writers to issue such a specification in this country.

It is a useful enough document, and contains a few new features. Part I. deals with the general and preliminary clauses, and Part II. with the more detailed specification clauses. The specification is perhaps, as one might naturally expect, drafted from the architect's point of view, and we find clauses inserted whereby the contractor holds the employer and the architect free from all claims of infringement or alleged infringement of patents. This seems to us an unfair clause in many cases where the contractor has to work to the designs of a specialist and, perhaps, to the designs of the architect, and it is hardly within his province to be an expert upon patent law, and especially is it impossible for him to ascertain whether patent rights are being infringed when he tenders and enters into a contract for work. We can quite well understand the specialist-designer being held responsible, or the architect taking the responsibility if he should design the work, but to throw the liability on the contractor is not the best solution of a difficulty. Of course, the contractor can, if he so choose, get an undertaking from the specialist to relieve him from responsibility of infringement, but if he raises such troublesome questions in the preliminary stages of a job—namely, when he is first endeavouring to obtain the work—things are not made any smoother.

We do not like a clause being introduced in a sort of surreptitious manner in the specification, regulating the method of measurement or the manner in which the quantities are to be taken out. Such a clause should be in the general conditions, where it would be more prominent, and also in the quantities, or, if there are no quantities supplied, in the form of tender. The contractor has a good deal to do, and we all know that he is required to deliver his estimate in a hurry, and such points as these get overlooked. It is all very well for the architect to shield himself in this way, but the contractor is often made the victim. The manner of measurement which Messrs. Scott and Fraser propose is that all concrete shall be measured the net sizes, no deduction being made, however, for the space occupied by the metal. That seems to us to be about the best way, but nothing is inferred as to whether the beams, columns and walls are to be stated separately to the floor slabs; a matter that is of considerable importance in tendering on quantities; the same in regard to the clause for centering which is to be measured the net area of the concrete face for which the centering is necessary, nothing being said as to the separation of beam, column and wall centering from the slab centering.

We notice a clause in which the architect reserves the right to vary the relative proportions of steel and concrete in the actual work without allowing an extra; this may be interpreted in an unfair, fashion. Supposing, for instance, a contractor tenders for putting in a certain number of tons of steel: if the architect likes he can afterwards insist on there being a lot more steel put in which may entail much more labour without the contractor being able to claim anything for the greater cost to which he is put. Again, we find another extremely inequitable clause in the contractor being required to carry out loading tests on any part or parts of the structure at completion to the architect's satisfaction. This means that the architect could require a contractor to go to very great expense in carrying out excessive loading tests on large areas. There should be some specification as to the amount of loading that will be required, so that a price can be included for same when tendering.

We notice clauses stating how the contractor shall center various parts of the work; such matters are usually left to the contractor, and a general clause provided enabling the architect to have his wishes attended to in case he considers anything likely to be disadvantageous to the work, but any detailed interference with the contractor in the case of centering seems to us unwarrantable. There are quite enough onerous restrictions without a contractor being governed as to the manner in which he shall carry out a job; he should at least be given the opportunity of displaying his ingenuity and intelligence in the direction of securing economy in centering. We notice that the surface of all centering, where next concrete is stipulated, to be thoroughly lime-washed or washed with a thin solution of soft soap and water to prevent adhesion. This, in our opinion, is another excessive provision. In the majority of cases it is only necessary to wet the centering for ordinary floors and beams when they have to be plastered afterwards. Provisions such as these might be inserted where a special finish is required; but, in the ordinary way, if clauses are inserted to secure properly dense concrete, the contractor might at least be left to employ economical methods without the often entirely unnecessary cost of lime-whiting or soft-soaping.

There is a good deal of elaboration in the clauses respecting the grading of sand and aggregate. Often the cost of such grading would not be warranted by the results obtained, the cost being more than the addition of extra cement to give the superior resistance. Furthermore, as long as one obtains a concrete that gives a required resistance, it is unnecessary to go to extra labour and cost to produce a concrete of higher quality, of which advantage is not permitted to be taken. The whole position taken by the specification, in our opinion, is illogical in this respect.

We think certain phrases in the preface a little out of place. It is hardly customary to find authors emphasising their "many years' experience and study" of a subject, or "the large amount of work which has been carried out under its stipulations"—*i.e.*, the specification.

Ready Reckoners for Reinforced Concrete Designs. By Frederick Rings, M.S.A.

Published by the Author at Bank Chambers, 92 Tooley Street, London Bridge, S.E. Octavo, 14 pp. with 4 large diagrams. Price 7/6 net unmounted; 10/6 net mounted.

In his book on "Reinforced Concrete," Mr. Frederick Rings included a diagram for the calculation of rectangular beams and slabs of reinforced concrete. He has now published a set of four similar diagrams based on maximum stresses of 500 lbs./in.^{2} for the concrete and 15,000 lbs./in.^{2} for the steel, and 600 lbs./in.^{2} for concrete and 17,000 lbs./in.^{2} for steel. Two of the set relate to rectangular beams and slabs, and the other two to T beams. The formulæ for the former permit diagrams of the form adopted to be accurate, but for T beams the form is unsuitable, and we find on trial the calculator to be only roughly approximate, and to depend upon certain assumptions which are not always warrantable in design. The diagrams give one fixed depth for any load and span, and are based on a fixed width of table of the T beam. If less depth must be used, Mr. Rings gives an approximate way of determining the compressive reinforcement, but says nothing about increasing the tensile reinforcement. He does not deal with increased depth of beam. Altogether, we are disappointed to find the calculators for beams of such very doubtful utility. Instead of their substantiating the author's intention that they should reduce risk of error in calculations, we fear that they might be more likely to increase it.

Surely there is some mistake in the title. It should have been "Rough and Ready Reckoners," etc.

"Engineering Construction in Steel and Timber." By William Henry Warren, *Wh.Sc., M.Inst.C.E., M.Am.Soc.C.E., Challis Professor of Engineering and Dean of the Faculty of Science and Engineering, University of Sydney.*

Published by Longmans, Green & Co., 39 Paternoster Row, London. xvi-472 pp. Large 8vo Price 18/- net.

Contents.—Stress, Strain, Elasticity of Steel; Properties of Cast-iron and Steel; Determination of Safe Working Load in Structures—Timber—Method for Determination of Stresses in Structures—Investigation of Bending Moments and Shearing Stresses; Influence Lines—Moments of Resistance and Shearing Stress in Beams—Bridges and Viaducts of Small Span—Timber Pile Bridges—Graphical Statics—Braced Girders with Parallel Cords—Bowstring and Other Trusses—Slope and Deflection of Beams, Trusses and Girders—Continuous Girders and Cantilever Bridges — Strength of Columns — Riveted Joints, Pins and Eye-Bars in Bridges; Joints in Timber Structures—Wind Pressure—Stresses due to Curvature and Use of Brakes—Stresses in Braced Pins—Approximate Weights of Girders and Trusses—Live Loads on Bridges—Concentrated Wheel-loads — Plate Web Girder Deck Bridge—Pratt Truss Bridges—Parker Truss Bridge—Swing Bridges—Arched and Suspension Bridges—Other influence lines.

The second edition of Prof. Warren's book is welcome. It contains much valuable information treated in a clear and concise way. Firstly, dealing with materials employed in structures and stresses in same, it proceeds to treat of bending moments, shear and deflection, strength of columns, etc., and bridges. The treatment of fixed and continuous beams is rather too sketchy, but any deficiencies are atoned for by the full treatment of special branches of the subject in which Prof. Warren has specially interested himself. In particular, we note some interesting and useful information on timber, columns and bridges, and original data of this kind render any book of value. It deserves a place in engineers' libraries.

"A Handbook of Testing Materials." By C. A. M. Smith, *M.Sc. (Eng.), Assistant Professor of Engineering, East London College.*

Published by Constable & Co., Ltd., 10 Orange Street, Leicester Square, W.C. Large 8vo. xii.-284 pp. Price 6s. net.

Contents.—Introduction — General Properties of Materials—Machines for Tension, Compression and Bending Tests — Strain-Measuring Instruments—Methods and Results of Tests on Materials — Torsion Testing—Impact and Hardness Tests—Shear and Miscellaneous Tests—Alternating Stress Tests—The Testing of Cements, Reinforced Concrete and Stones—The Testing of Timber—Experiments in College Laboratories—Standard Results of Tests on the Strength of Materials—Admiralty Rules for Testing Materials for Machinery — Researches on Combined Stress—Heat Treatment of Steels — Bibliography — Useful Constants.

The subject of testing materials is of the greatest importance in engineering practice. Far too little knowledge is ordinarily possessed of materials. Many persons design structures without ever having really obtained a knowledge of materials first-hand by experimental testing. This is a great pity, for such designing must be inefficient. The successful *engineer* is the one with a first-hand knowledge of materials. That stamps the practical engineer, and those with such knowledge who are even deficient in grasp of higher theory have mostly been responsible for our great engineering works. We therefore take the keenest interest in this branch of the subject, which is perhaps more appreciated by cement users than by engineers, because the necessity of constant testing is recognised as of first importance. We gladly welcome the appearance of this book by Mr. C. A. M. Smith, who has done much in increasing our store of knowledge respecting the mechanical properties of materials. His book is admirable in form and matter, and it should help to impress the professional public with the importance of testing materials. His work is mostly concerned with metals, and the references to cement and concrete are few and not of much value, but the book will repay the study of everyone connected with the building and engineering trades. It is particularly useful in bringing our knowledge right up-to-date, for in the last few years a good deal has been done to show the effects of combined bending and direct loading, from which we may judge generally that failing in ductile materials is by shear, and in brittle materials by tension. We hope to see many fresh editions of this book, which will give the opportunity for Mr. Smith to record the information which is fast being accummulated by him and other enthusiastic workers. There is much to find out, especially regarding reinforced concrete.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE WATER TOWER AT WESTERLEY, R.I.

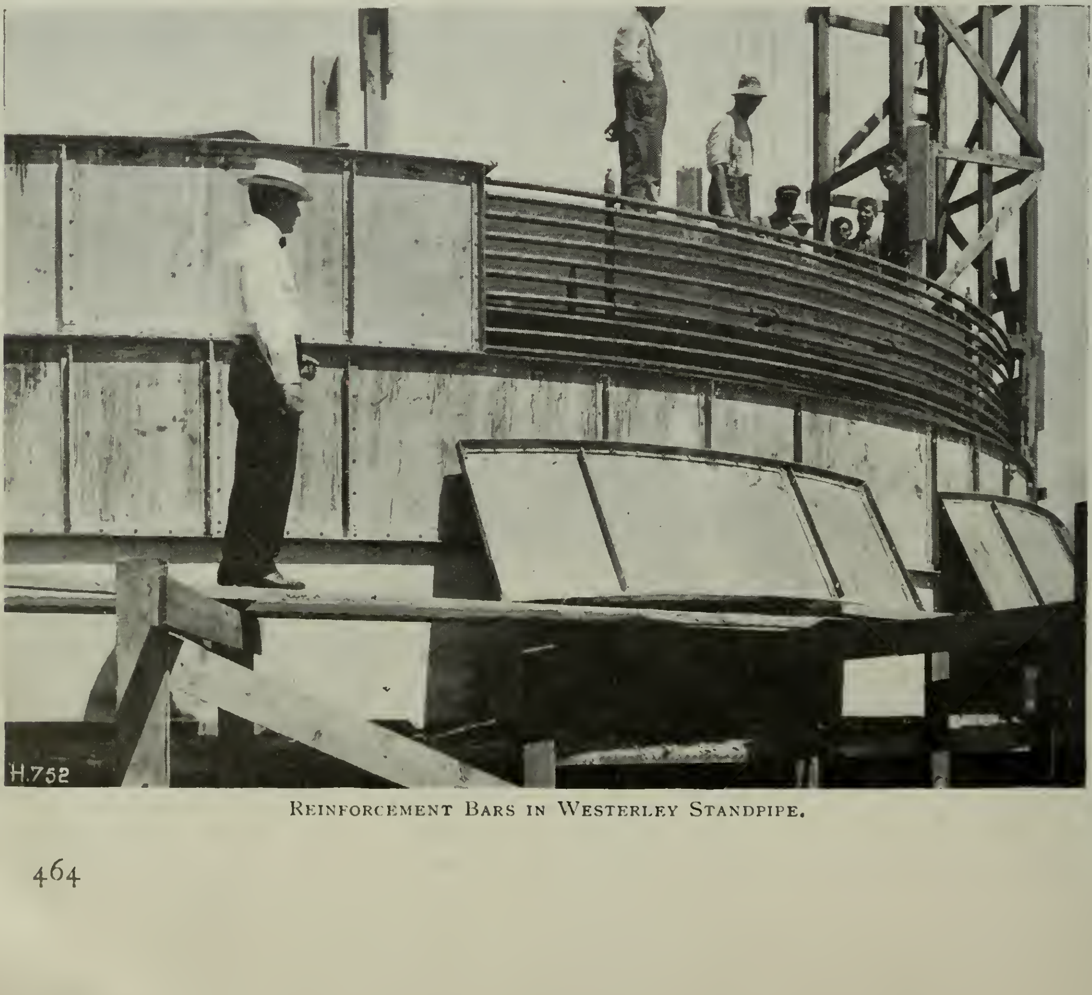
Some interesting features are developed by the Aberthaw Construction Company of U.S.A., in the methods which they employed in the construction of the reinforced concrete water tower, recently completed at Westerley, R.I. The accompanying photographs show the tower completed, and details of the steel forms and the movable steel staging used on this job.

The standpipe is designed for a capacity of about 650,000 gals. of water, being 40 ft. inside diameter with a head of 70 ft. The tower rests on a concrete slab 44 ft. in diameter, and 12 in. thick, which is reinforced with a network of $\frac{1}{4}$-in. rods, spaced 6 in. on centres, running at right angles to each other, 2 in. below the top.

At the slab the walls are 4 in. thick, rising with a batter of 2 ft. 5 in. on the inside, which, with a step-in of 10 in. at the water table, brings the wall to its ultimate thickness of 14 in. at a point 5 ft. above the top of the floor slab, at which thickness it remains clear to the top.

The tower is covered with a low red Gustavino tile dome, the drainage from which will be collected in a gutter located in the cornice, and discharged to the ground through a leader.

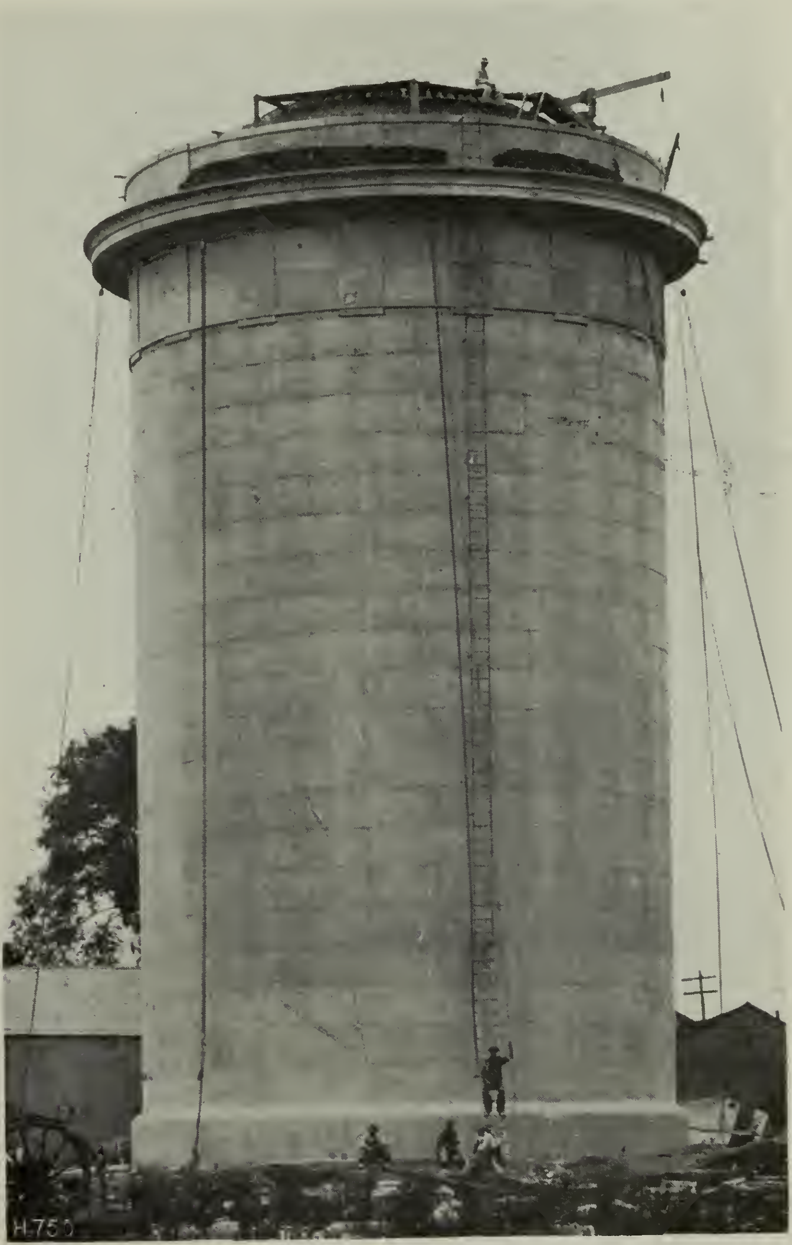
The wall reinforcing consists of twelve vertical $1\frac{1}{2}$-in. pipe columns made in 3-ft. sections, connected by ordinary pipe couplings, spaced at equal distances, and extending from the bottom of the floor slab to the cornice. These pipe columns have drilled in



Reinforcement Bars in Westerley Standpipe.

them ¼-in. holes spaced the proper distance apart for attaching the horizontal reinforcing rods. These rods consist of fifty 1½-in. bars in the first 10 ft. from the base, thirty 1½-in. bars in the second 10 ft., then twenty-five 1½-in., thirty-four 1⅛-in., twenty-five 1⅛-in., fifteen 1⅛-in., and ten 1⅛ in., in each succeeding 10 ft.

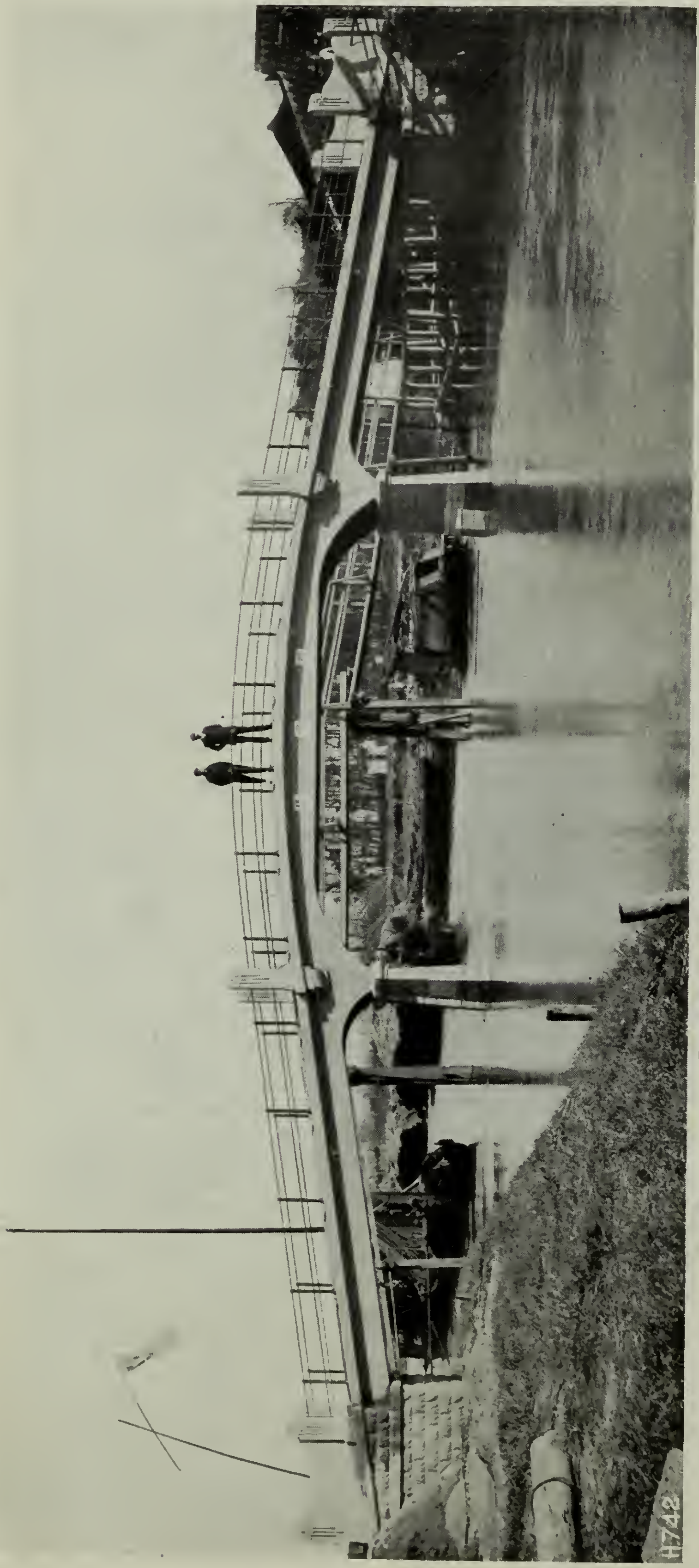
The horizontal reinforcing bars are bent around the outside of the pipe columns and attached to them by ¼-in. round clamps, as shown in the accompanying illustration. In the first 5 ft. 8 in. from the bottom the bars are doubled, being clamped to the inside and outside of the pipe columns.



REINFORCED CONCRETE WATER TOWER AT WESTERLEY, R.I.

The steel forms are made of 3 in. by 3 in. by ¼-in. angles, and ⅛-in. boiler plate. The inside form is 6 ft. high, and has a key section in which the plates lap about 6 in., and on either side of the joint angles are securely riveted to the plates and connected by short turn-buckles, so that the whole form can be sprung in and reduced in diameter so as to make it possible to raise it when necessary. The outside forms are made in seven segments to the circle, in sections 3 ft. high. On the outside forms all the rivets are countersunk, and the face of the angles making joints are machined so as to secure a perfectly smooth fit, thereby securing a practically smooth finished surface.

As the tower had to be made water-tight by the density of the concrete, great care was exercised in the choice of aggregate and cement, and in the methods of placing and mixing. One yard of stone to 1 yard of sand, $2\frac{5}{11}$ barrels of cement to 1 yard of concrete, and about 5 per cent. of hydrated lime was about the average mixture used. The floor and the battened sides up 5 ft. are finished with a granolithic surface.



Reinforced Concrete Bridge at Pootnung, Shanghai.

REINFORCED CONCRETE BRIDGE AT POOTNUNG, SHANGHAI.

This bridge is constructed over the Piehien King, a tidal creek with large boat traffic. The shore here being very flat, and not much above high-water level, it was found necessary to follow the line of the Chinese bridges, and have on the main creeks a height of at least 10 ft. clear in the centre of the principal span at high tide, so as not to interfere with the boat traffic.

The girders of the bridge are designed and calculated as continuous beams, resting free on the abutments to avoid any cracks resulting from uneven settlement, elasticity, and the influences of temperature.

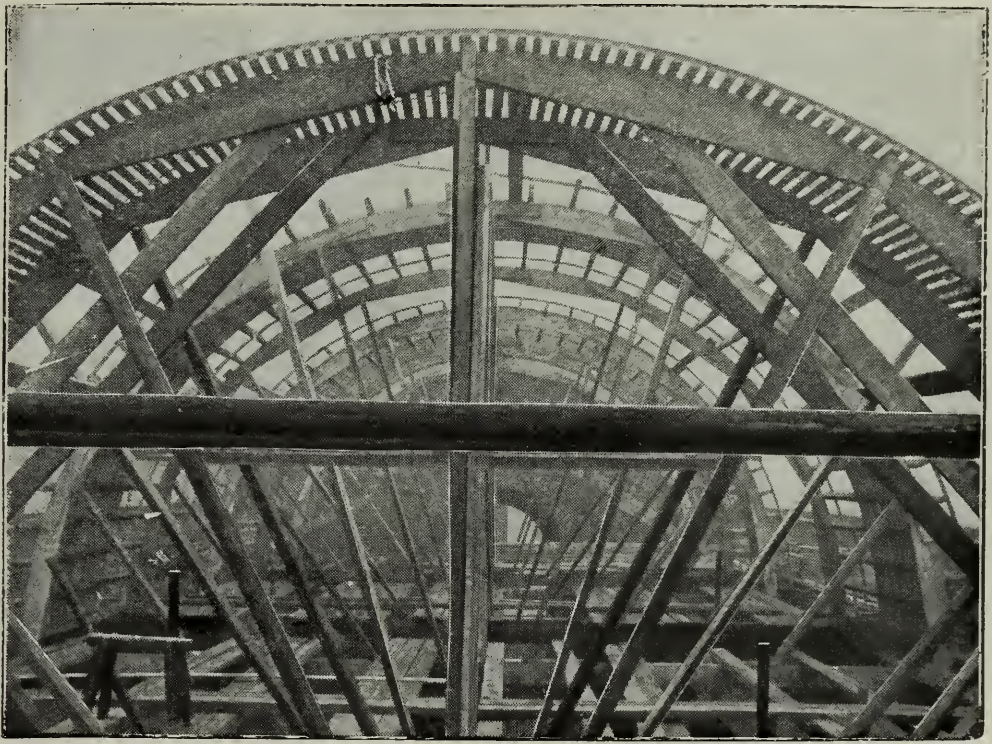
The reinforcement of all members of high tensile strength consists of Johnson indented steel bars, the remainder being reinforced with round wrought iron.

The foundations of the abutments rest on Foochow pole piles, and each pillar rests on seven reinforced crete piles. To save material and weight, each pillar consists of twelve columns carrying the two main girders of the bridge.

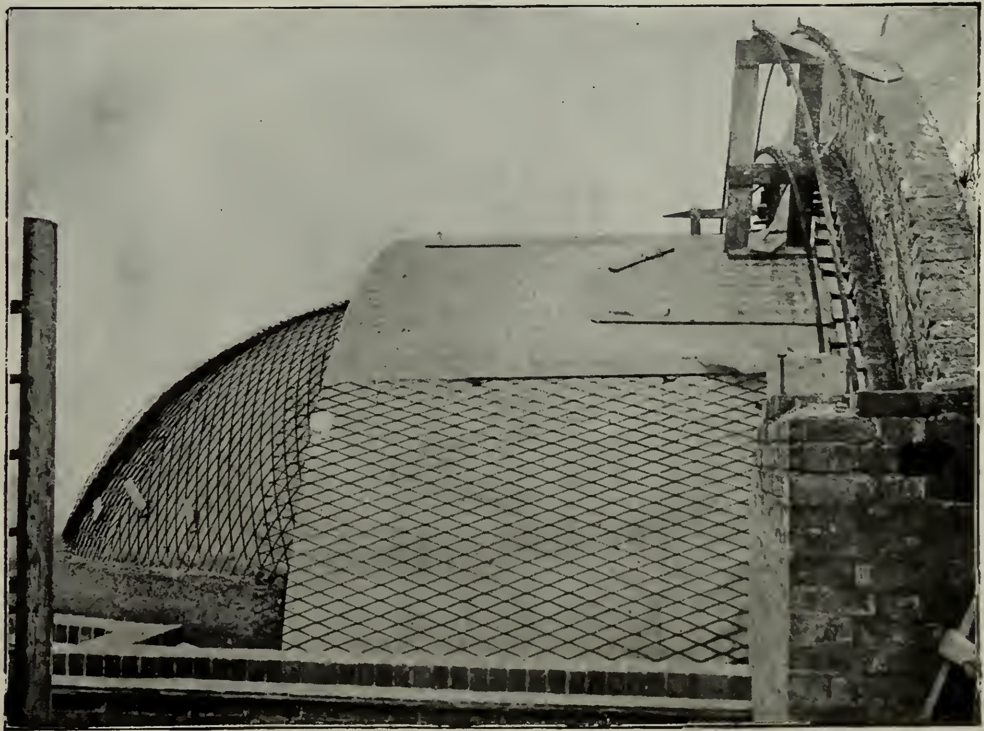
ST. BARNABAS CHURCH, DALSTON.

HERE we have an example of church roofing in reinforced concrete.

The building, with the exception of the roofing, is constructed throughout of stock bricks. The main side walls supporting the roof, and one end wall, are carried

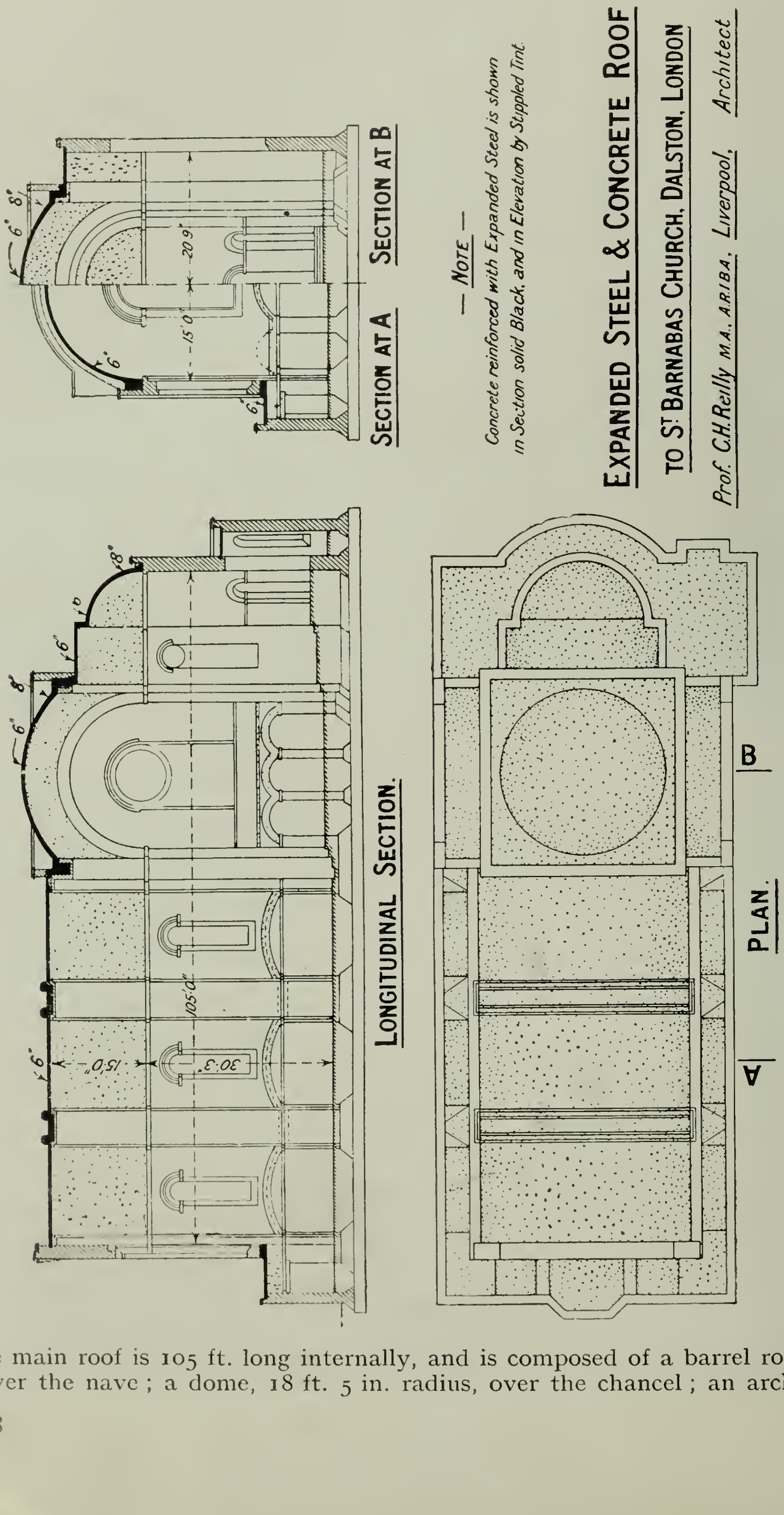


SHOWING TEMPORARY TIMBERING FOR NAVE ROOF, NEARING COMPLETION.



SHOWING EXPANDED STEEL REINFORCEMENT FOR APSE ROOF, IN POSITION.

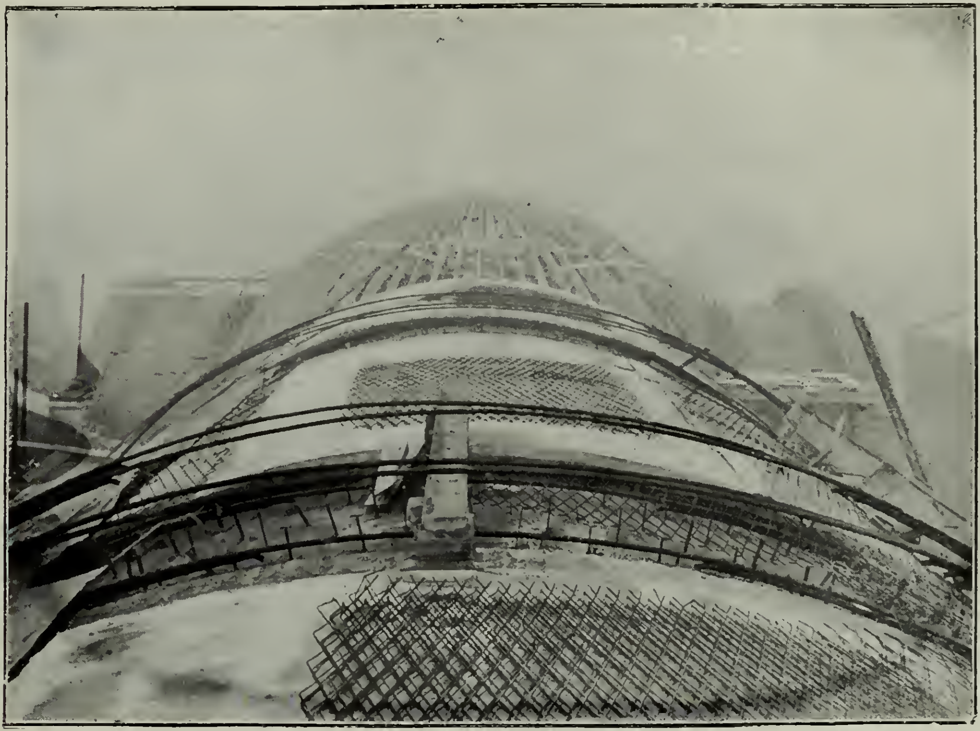
on heavy reinforced concrete arches, which in turn are supported on piers; these arches are continued back, and form the roof of the ambulatory. The organ gallery is also formed in arches and slabs of concrete reinforced with expanded steel.


Section at A
Section at B
— Note —
Concrete reinforced with Expanded Steel is shown in Section solid Black, and in Elevation by Stippled Tint.
6"
8"
6"
6"
15'0"
20'9"
Longitudinal Section.
6"
8"
6"
6"
8"
6"
105'0"
15'0"
30'3"
Plan.
B
A

Expanded Steel & Concrete Roof
to St Barnabas Church, Dalston, London
Prof. C.H. Reilly M.A., A.R.I.B.A., Liverpool, Architect

The main roof is 105 ft. long internally, and is composed of a barrel roof, 30-ft. span, over the nave; a dome, 18 ft. 5 in. radius, over the chancel; an arched roof, 20 ft. 6 in. span, and a semi-dome roof, 8 ft. 6 in. radius, over the apse. The height to the springing of the roof is 30 ft. 3 in. from the finished floor of the nave.

The barrel roof over the nave is carried by external ribs. The soffits of these ribs, and the soffits and sides of the four arches carrying the main dome, are faced with stock bricks in cement tied by bonding irons to the concrete; this brickwork facing, which forms bands or rings, is a shell, and was not calculated to assist the reinforced concrete in any way.



Showing Nave Roofing in Progress and Temporary Timbering to Dome nearing Completion.

In addition to the above, expanded steel concrete flat roofs were formed over the morning chapel and heating chamber.

The whole of the roofing is covered with $\frac{3}{4}$ in. of "Seyssel" asphalte, put on in two layers, for waterproofing purposes.

The architect for the work was Professor C. H. Reilly, M.A., the contractors were Messrs. L. H. & R. Roberts, Islington, and the Expanded Metal Co., Ltd., the sub-contractors for the whole of the reinforced concrete work.

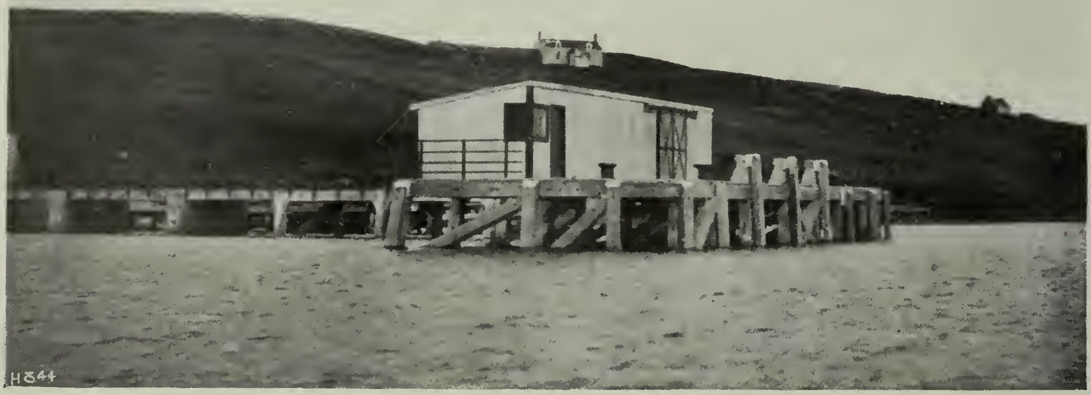
NEW USES FOR CONCRETE
AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

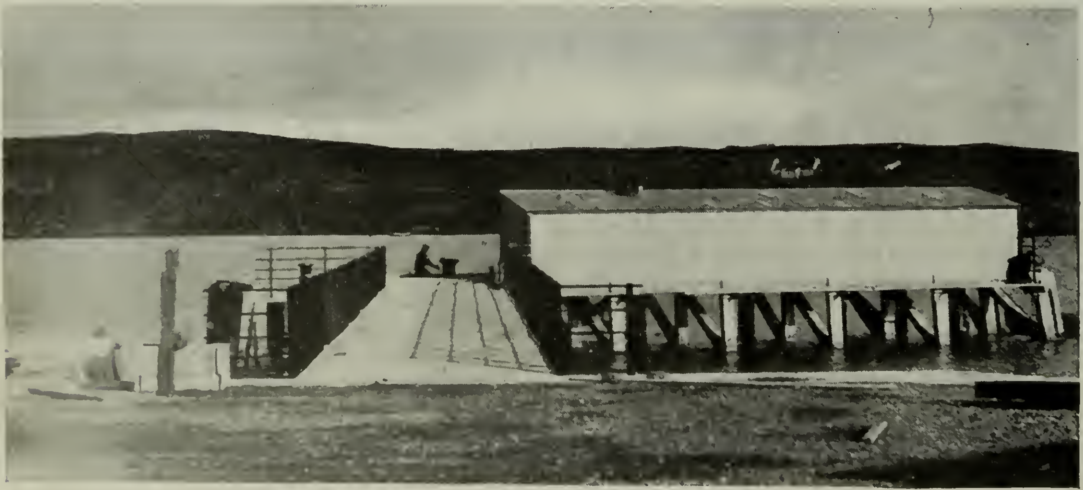
SMALL PIERS OF REINFORCED CONCRETE.

We are illustrating a small pier in the Shetland Islands, built of reinforced concrete, with the view of indicating the utility of this material for small works in which it was formerly usual to apply timber.

Vaila Harbour is a bay, or boe locally called, on the west coast of Shetland, 20 miles north of Scalloway, the principal west side harbour of Shetland, celebrated for its herring fishing and curing. Walls is the village served by the weekly steamers which call at Vaila Harbour, and it is the centre of a large and populous district for a radius of 30 miles, in which cattle, ponies, and sheep are reared and exported to the south. It is also visited by anglers for good sea trout fishing, and there is some herring fishing in the season.



Reinforced Concrete Pier at Vaila Harbour, Shetland.



Reinforced Concrete Pier at Vaila Harbour, Shetland.

The pier, for the use of the steamers, has been built by the aid of the Congested Districts Board for Scotland, and by the local subscription of the landowner, Mr. H. Anderton, of Vaila, whose residence is Vaila Castle, on the Island of Vaila, which closes the bay from the Atlantic Ocean. The pier is built of reinforced concrete on

Reinforced Concrete Railway Sleepers, Pennsylvania, U.S.A.

the Hennebique system, and was designed by Mr. Woulfe Brenan, M.I.C.E., of Oban.

The pier head is 80 ft. long, 24 ft. wide, and contains steamer offices and storehouse. The approach is by a viaduct 113 ft. in length, carried on reinforced concrete piles and flooring, and the landward end is formed of concrete walling and quayage, and a boat slip of the same construction. The depth at the pier front is 16 ft., and the sea bottom is composed of large boulder gravel of massive size, into which the piles were driven with some difficulty. The contractors were Messrs. R. Thorburn & Son, of Edinburgh, and the Engineer inspecting for the Government Department was Mr. A. Coles, engineer to the Secretary for Scotland. Mr. W. A. Knight was joint Clerk of Works for the Government and the Harbour Trustees.

The pier was opened for traffic in February last.

REINFORCED CONCRETE RAILWAY SLEEPERS.

THE question has frequently been ventilated whether reinforced concrete railway sleepers are suitable for high-speed traffic. We thus illustrate some sleepers used on a high-speed hard surface track of the Pennsylvania lines by way of trial for a period of three years, and we understand that these sleepers hold the surface better than the usual wooden sleepers, as they are heavier and bed better. The sleepers here under investigation are advocated by Mr. Riegler,

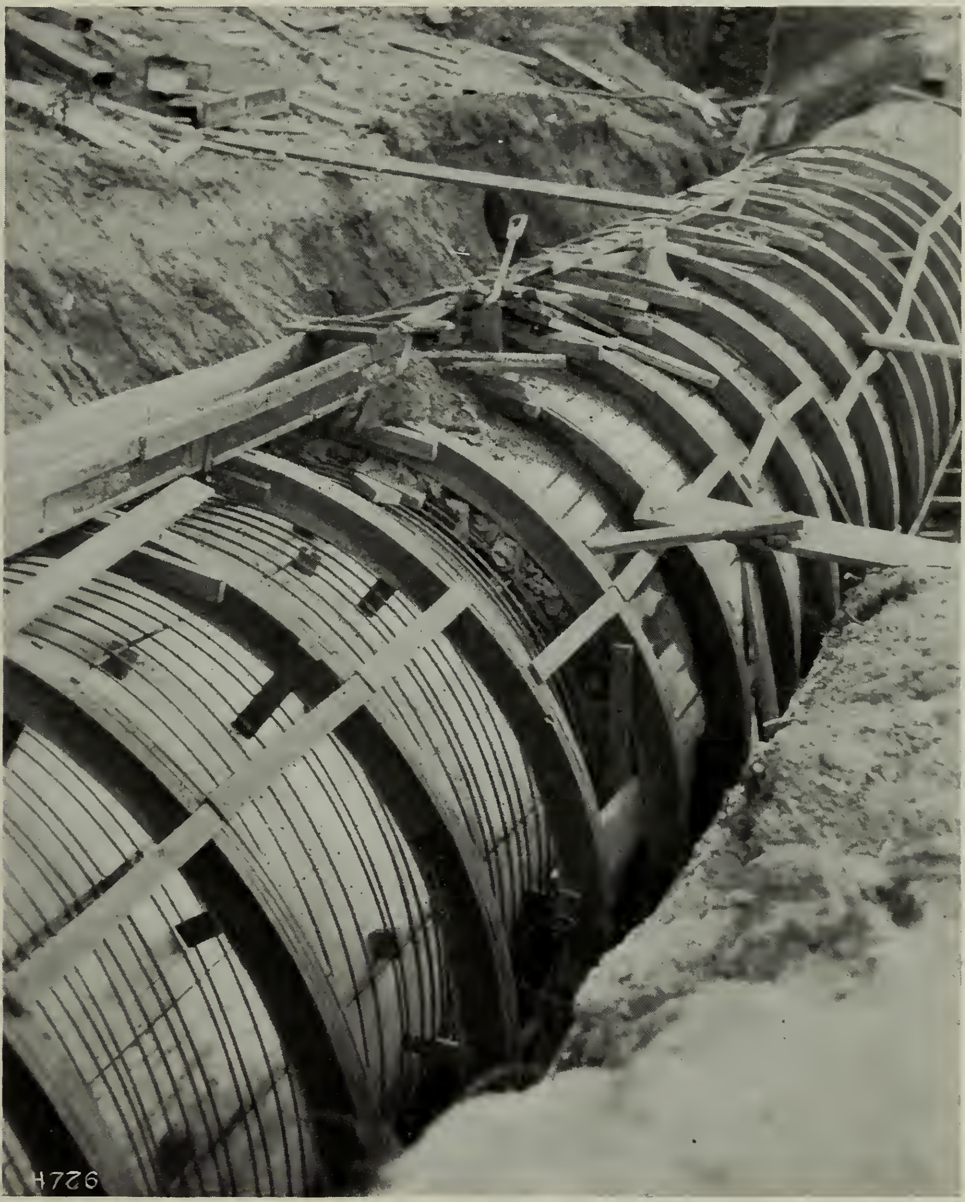
Reinforced Concrete Fence Posts, Swanscombe.

and have been found to be more satisfactory than some others that have been under test. It should be specially mentioned that the trains passing over the sleepers illustrated are generally very long ones of heavy tonnage.

Particulars can be obtained by applying to Mr. L. Riegler, North-West System of Pennsylvania Lines, Pittsburg.

FENCING.

WE have frequently referred to the advantages of reinforced concrete for fencing. There is no necessity for us to enter into the discussion of the subject again, but we illustrate some recent fencing put up very economically at the Associated Portland Cement Manufacturers' works, near Swanscombe. The fencing runs through Swanscombe Wood at Galley Hill, and full particulars can be obtained from the Associated Portland Cement Manufacturers' Gravesend office.



REINFORCED CONCRETE SYPHON, LOS ANGELES.

REINFORCED CONCRETE SYPHON.

THE Los Angeles aqueduct involves numerous syphons required to cross depressions below the hydraulic grade line. It was originally intended to use steel pipes for these syphons, but later it was decided that they should be constructed of reinforced concrete.

A site was chosen about 30 miles from Los Angeles, where the aqueduct crosses the drainage of the country and passes through the foot-hills of the mountains on the coast, so that the construction consequently consists of a series of tunnels through the hills and syphons across the intervening valleys. The lowest point of the valley across which the reinforced-concrete syphon has been built is 65 ft. below the hydraulic grade line of the aqueduct. The syphon connects the portals of two tunnels on opposite sides of the valley, and has a total length of 955 ft. As the sides of the valley adjacent to the portals of the tunnels are on steep slopes most of the syphon operates under a head close to the maximum.

A water course in the valley that is crossed carries a large flow during flood periods. In the lower part of the valley at the crossing the soil consists of coarse gravel and sand, while the hillsides are of hard clay. The syphon was therefore located in an excavation deep enough to secure a minimum cover of about 1 ft. over its arch. Thus all liability of danger from scour was considered to be eliminated. At the lowest point on the syphon a 10-in. blow-off pipe was provided, with a gate valve in a 3 ft. by 4 ft. concrete chamber, which was constructed as a part of the concrete in the syphon. A vent, consisting of 650 ft. of second-hand 12-in. pipe, embedded in concrete, carried the water to a point in the valley about 1 ft. in elevation below the bottom of the syphon.

The interior diameter of the syphon is 10 ft., and the uniform thickness 9 in. the full length of the syphon. It is reinforced with plain round rods, the concrete consisting of a mixture of one part Portland cement, four parts sand and gravel. The concrete was mixed quite wet, and was thoroughly spaded in the forms, in order to secure a shell as nearly water-tight as possible. The forms for the syphon were built in 6-ft. lengths, each 6 ft. form consisting of eight sections, each section having 2-in. plank ribs cut to the curve of the inside of the syphon. These ribs were spaced 2 ft. apart on centres, and were nailed at both ends to a horizontal 2-in. plank, these planks on the abutting edges of the section enabling a smooth joint to be secured on the outside. The ribs were lagged with 2 in. by 6 in. pieces, dressed on the exposed side, and with their edges cut to the radial lines of the circle of the syphon.

Small concrete blocks were set up in pairs on the bottom of the trench, to provide a support for the lowest section of the forms. These blocks were made 4 in. thick, 12 in. wide, and about 12 in. high, with their tops cast to the curve of the inside forms of the syphon. They were spaced uniformly, 6 ft. apart, in two parallel rows, so that each end of each bottom section of the 6-ft. lengths of forms was carried by a pair of them. This arrangement ensured the correct alignment and grade of the forms, and also permitted the concrete to be poured readily, since the small blocks became a part of the shell.

Work was started on one side of the valley and carried up the adjacent slope. Forms were built for a length of 120 ft. of the syphon, and the inside forms were all set up in place before the concrete work was started. The two side sections of each length of forms below the horizontal diameter of the latter were seated on the bottom section, and were held together at the top by a 4 in. by 4 in. cross brace. These braces also engaged the bottom of the sections at the haunches of the arch. The latter sections and the two directly above them were cross-braced at their junction in the same manner. As soon as each eight sections of a 6 ft. length were placed, the circular reinforcing rods were put around them so these rods could be distributed later without difficulty. When the inside forms were ready, the circular reinforcing rods were spaced properly and blocked up in place from the forms. Then circular ribs were set to support the outside forms of the barrel of the syphon.

The method of pouring the concrete was first to fill the bottom of the trench for a length of 40 ft. Then the outside lagging, consisting of 2 in. by 6 in. pieces of the same length as the lagging of the inside forms, was set to a height of about 2 ft. on both sides for a length corresponding to the amount of concrete base already poured. When the concrete reached the top of this lagging more of the latter was set, and so on until the length of the syphon on which work was in progress had been completed.

The results obtained were entirely satisfactory. After the first half of the total length had been completed, it was backfilled, and then a pool of water was allowed to stand over the backfill for some time subjecting the concrete to an external head of 5 ft. to 8 ft. Under this head the interior of the syphon was absolutely dry, not even a sweat occurring after the concrete had hardened thoroughly.

The syphon was built at a cost of about £4 4s. per foot, including all expenses, supervision, and engineering, but excepting administration and the depreciation of construction plant. Mr. Wm. Mulholland, M.Am.Soc.C.E., is the chief engineer, and Mr. J. B. Lippincott, M.Am.C.E., assistant engineer of the aqueduct. Mr. D. L. Reaburn, M.Am.C.E., engineer of the Saugus division, had direct supervision of the construction of the syphon, and Mr. A. P. Cox, superintendent of construction, was immediately in charge of the construction.

POLYCHROME CONCRETE.

A MATERIAL which hardens into permanent stone, the component parts of which may be pre-selected and modelled into shape to meet the requirements of the use and fancy of the designer, has the distinct advantage of obtaining both colour and texture at a cost far below that of cut stone.

Our illustration shows the polychrome concrete vase exhibited at the Architectural League, Fine Arts Building, New York, during February, 1911. The materials used for this vase were "Vulcanite" Portland cement, crushed black and crushed yellow marble screenings, all passing through a 8 screen ($\frac{1}{8}$ in. mesh), black and yellow marble chips, all passing through a $\frac{1}{2}$ in., and all collected on a $\frac{1}{4}$-in. screen.

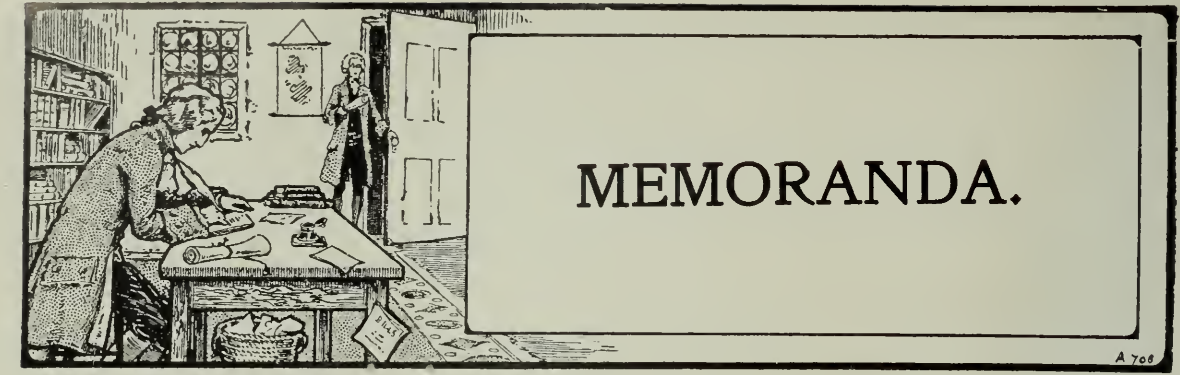
Polychrome Concrete Vase

These aggregates were mixed medium wet and moulded in a plaster mould. As soon as the concrete was hard enough to hold in shape, which took about 48 hours, the inside core was removed. Inspection would then show as to whether it was safe to remove the outside mould. If sufficiently hard, the outside mould was removed and the surface immediately scrubbed with a stiff house scrubbing brush and water. If this failed to remove the surface coating of cement, a wire brush was used. The concrete was brushed until the larger aggregates all appeared, and in order to obtain texture the brushing was continued until they were thrown slightly in relief.

The vase was then cleaned off with water and kept damp for a couple of weeks, after which it was washed off with a solution of dilute muriatic acid, 5 parts water. The acid was left on for a couple of minutes, and then scrubbed off with clear water and a scrubbing brush.

The effect as to colour, texture, and form is permanent. The bonding material (Portland cement) is removed from each particle of stone, there being no artistic, practical, or technical reason why the bonding material alone should be displayed to the eye.

This opens up a wide field for garden ornaments, decorative panels, and balustrades for bridges, etc. The method and effect undoubtedly comply with all the fundamental principles of art.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Methods of Giving Concrete a Polished Surface.—A great deal of attention has been given to, and many experiments made for, the discovery of a practical method of producing polished concrete.

A process for this purpose is not impossible, says Mr. A. A. Houghton, and while it is yet unperfected for practical work, it is easily seen that the present manner of moulding concrete must be changed to secure surfaces upon which to work.

Any stone that is compact or with a very fine grain will take a polish to a greater or less degree under friction. Concrete, made with Portland cement in the usual manner, will not give a polish under friction. The cement crystals filling the voids between the particles of the aggregate occupy a large portion of the surface of the work, and while penetrating all penetrable surfaces of the aggregate and cementing all parts in a most tenacious manner, yet these cement crystals are soft and yielding in composition in comparison with the aggregates they unite. When subjected to friction or any grinding force they are easily reduced to a powder without securing a smooth, hard surface capable of reflecting light.

There appear to be two solutions of this problem which should lead to successful results. One is the perfection of a material which has all the cementing properties of Portland cement and the polishable properties of Keene's cement on recalcined plaster-of-Paris.

Another and a more ready method would be to incorporate the aggregate in the slab or block of concrete with the least possible amount of Portland cement upon the surface. Thus, if the aggregate were lightly sprinkled into the mould in a clean, dry state, so as to cover the surface of the mould, and the concrete tamped upon this layer, to cement the dry aggregate firmly in the body of the work, with the cement upon the under side only, the result would be a face composed entirely of rock which might be polished.

Another procedure along this line would be to cover the surface of the work with dry aggregate, while still in the mould, and by pressure embed it in the concrete, so as to cement the aggregate upon one side only, with the minimum of cement between the particles of stone.

To mould concrete with a smooth, glossy surface would depend upon a very smooth moulding surface. Where the work is a flat slab or block, sheets of glass may be employed for this moulding surface. To line the surface of the mould with sheets of glass cut to the right size is very simple, far more so than to mould the work against the glass—to avoid all chance of air-bubbles or small holes in the moulded work. The only way to avoid this is to place a very thin coat of rich concrete against the glass; this, when of a thickness of $\frac{1}{4}$ in. to $\frac{3}{8}$ in., permits the trowel to press the surplus water to the surface and away from the glass, making the mortar, directly against the glass moulding surface, as compact as possible. This could also be done by subjecting this thin coating of concrete to heavy pressure, so that surplus moisture would be drawn away from the outside surface. This thin coating of mortar is then easily backed up with mortar placed and finished in the usual manner, and if the first concrete placed against the thin mortar coating is semi-moist it will help to absorb the surplus moisture.

The use of any waterproof enamel coating over a metal surface will, if properly applied, give as satisfactory a moulding surface as sheets of glass. This will be of greater value, as it may be applied to a wider variety of uses than the glass surface.

It should be pointed out that experiments proved that concrete has a very slight tendency to stick to the surface coated with enamel; thus enabling the mould to be removed from the work without injury, even where a very wet mix is employed. Considering the fact that the enamel could be easily placed upon any metal moulding surface and into all its lines, thus giving a moulding surface that would not stick to the green concrete, and at the same time producing a finish like that of polished stone, this should be of great interest to every concrete worker using metal moulds, as it can be easily applied to the moulding surface. When it is properly done so as to secure a smooth and perfect coating of the enamel over the metal, there would be no cause for trouble with a wet mix, in the face-plates sticking to the work.

Frozen Concrete.—Frozen concrete, as a rule, cannot be detected by ordinary inspection from concrete laid under natural conditions. Cutting out a piece, placing it on a hot stove, and seeing whether it sweats and softens is the only reliable guide to determine whether the concrete has been merely stiffened up by frost or has actually set to an extent which would warrant the builder in trusting its strength.—*Engineer.*

Testing a Cellular Reinforced Concrete Floor.—While the Génie Civil Pavilion of the Brussels Exhibition was being pulled down, opportunity was taken to test *à outrance* the cellular reinforced-concrete floor that had been laid on the Herbst system, calculated to support a load of 300 kg. per sq. m. (61·4 lb. per sq. ft.) uniformly distributed. The floor, 7·2 m. (nearly 24 ft.) between supports by 1·3 m. (over 4 ft.) wide, was composed of five rolled joists, 24 cm. (9½ in.) deep, steel-trussed, and the space between them filled in with concrete. On the floor being loaded to one and a half times its calculated resistance, it showed a deflection in the middle of 2·2 mm., equal to 1/3722 of the span; and, on the load being taken off, a permanent deflection of 0·2 mm., or 1/3600 of the span, was observed in the middle. After successive chargings to 2, 3, 4, 5, 6 and 7 times the calculated resistance, uniformly distributed and taken off before each increment, the corresponding deflections were recorded. Under a load of 1,800 kg. per sq. m. (368 lb. per sq. ft.) the first fissures were noticed in the upper zone; and at 2,100 kg. per sq. m. (430 lb. per sq. ft.) a slight fissure showed itself at the middle of the lower zone. Under a load of eight times the calculated resistance, *i.e.*, 2,400 kg. per sq. m. (491 lb. per sq. ft.) the floor still held good, though the fissures had slightly increased. For bringing about complete down-throw, the load was concentrated in the middle, and increased to 3,250 kg. per sq. m. (665 lb. per sq. ft.), when at length the floor gave way. The results were watched by a commanding officer of the Engineer Corps, representing the War Minister.—*The Contract Journal.*

An Interesting Research has been carried out in the Natural Philosophy School of the University of Melbourne by the aid of funds furnished by the Government of Victoria, Australia, with the object of determining the effect of electric currents on reinforced concrete. The series of tests tends to prove: (1) That the rusting and pitting of reinforcing and structural steel occurs at the anode; (2) that this rusting, by its growth, causes rupture of the concrete and the development of large cracks; (3) that very small currents—*e.g.*, 0·02 amps., will cause such rusting and cracking; (4) that when steel is cathode no rusting of the steel or cracking of the concrete will occur with currents up to 0·06 amps. during 200 days; (5) that sandstone and brick will behave similarly to concrete, showing even less resistance to cracking; (6) that damp earth supplies sufficient moisture to concrete to render it conducive to a current which will cause cracking; (7) that alternating currents of the magnitude of 3 amps. will produce cracks by thermal action, but no rusting; (8) that the thermal action when measured by a thermometer of currents of the magnitude of 0·05 amps. is negligible in blocks of concrete.—*The Building News.*

Clydebank and District Water Trust have just completed an important part of their new water scheme. As is known, the trustees, for the first time in the United Kingdom, adopted the Bonna system of reinforced concrete pipes for the conveyance of water for public supply purposes. When the resolution was come to, there was some misgiving in many quarters as to whether their substitution for the usual cast-iron pipes would realise all that was expected of them. It is claimed for the Bonna pipes, apart from the advantage of being cheaper, that they last longer, and are immune from the corrosion and rust associated with iron pipes. The work has now been brought to a successful completion. The final tests revealed not a single leakage. The main is now discharging water to the filters at Cochno from Burncrooks, a distance of about eleven miles. The cost of the undertaking, even taking into account the repairs that were necessary when the company who held the contract retired, will turn out less than the lowest offer for iron pipes. Deputations from different corporations visited the work while it was in progress, and it is considered that any bad impression will be removed by a contemplation of the completed undertaking. Indeed, now that the merits of the Bonna system of pipes for the conveyance of water have been established, it is expected that they will not be overlooked by other public bodies.

Concrete Stairs.—A flight of stairs has been erected in Paris over which 14,000,000 persons have passed without so much as scratching the surface. These steps are almost imperishable, for in the concrete of which they are constructed a generous proportion of carborundum has been introduced, and since carborundum is almost as hard as the diamond, it has given the concrete a wearing quality which no marble or granite could possibly approach.

Subsidence at Bank of England.—Owing to the subsidence of the foundations of the Bank of England at the Princes Street corner it has been necessary to resort to underpinning. It was first discovered early in the year that something was wrong, for a subsidence then occurred which was signalised by a loud report heard by the clerks in the bill office, and left its effects in a large crack in the building near the ground. The work of underpinning was undertaken as soon as practicable. A raft of solid concrete 6 ft. thick is being inserted under the outer walls at the Princes Street corner, the wooden piles on which the structure has stood for about 200 years being cut away for the purpose.

Experiments on Oil-Mixed Cement Mortars and Concretes.—The Office of Public Roads of the United States Department of Agriculture has sent us the following information :

It was found a year ago last October at this office that almost any oil could be mixed with Portland cement after it was thoroughly wet, the oil combining with the cement and quickly disappearing throughout the mixture. This was also found to be true of mortars and concretes. In adding the oil to mortar, the cement, sand and water are mixed together as in ordinary mortar, the oil being the last ingredient added. Oil-mixed concrete is best made by mixing the cement, sand and water to a mortar, adding the oil to this mixture, and mixing until the oil is thoroughly incorporated. This oil-mixed mortar is then combined with the previously moistened coarse aggregate.

Tests have been made on the compressive strength of oil-mixed mortars and concretes in comparison with plain mortars and concretes. It has been found that although the addition of the oil causes a decrease in the strength, this decrease is not serious with the addition of oils in amounts up to 10 per cent., based on the weight of the cement in the mixture. One year tests in compression show that oil-mixed concrete gains in strength with time, this being true of both air and water-cured specimens. One to three mortar specimens cured in air and containing 10 per cent. of oil have shown a strength of 1,500 lb. per sq. in. as against 1,600 lb. per sq. in. for the plain mortar specimens. Ten per cent. mortar specimens cured in water have shown a strength of 2,200 lb. per sq. in., as against 2,350 lb. per sq. in. for plain mortar specimens. The time " set " of mortars and concretes mixed with oil is somewhat delayed. The final " set " of neat cement mixed with 10 per cent. of oil is 60 per cent. longer than that of plain neat cement. It has been found that the addition of 10 per cent. of oil renders 1:3 mortar impermeable under high pressure. The absorption is likewise decreased.

In May, 1910, streets were constructed of oil-mixed concrete : one in New York City, one in Washington, and two bridge surfaces in Ridgewood, New Jersey. Some months ago a vault 105 ft. long by 18 ft. wide was constructed in the Treasury Department of this material. The top was a flat reinforced concrete arch, and as sufficient tests in bond had not been made, ordinary concrete was used to surround the reinforcement. After it had set, 3 in. of a 10 per cent. oil mixture was placed above. The vault has been perfectly waterproof under very trying conditions. A large water tank constructed in our laboratory with a 10 per cent. oil mixture is absolutely waterproof. Extensive experiments made with oil concrete used in basement floors have given excellent results up to the present time.

The oils that have been used to date have been non-volatile petroleums with flashpoints of at least 350°.

Test of a Concrete Telegraph Pole.—A concrete telegraph pole of the Siegwart type was recently tested at the factory in Lucerne in order to determine its resistance to bending, the load being applied at a distance of 4 in. from the top in order to secure loading similar to that to which the pole is subjected in practice. The pole was 26·24 ft. long, and its lower end was embedded horizontally for 4 ft. in a masonry wall. The pole was hollow, about 10 in. in external diameter at the lower end, and about 7½ in. at the upper end. The annular wall was 1·2 in. thick, reinforced with thirty-two ¼-in. round rods at the base, and wrapped with steel wire of small size. The deflection was measured by a scale at the end. According to "Beton und Eisen," the pull required to stress the steel to the permissible 14,200 lbs. per sq. in. was computed as 409 lbs. The load was applied in increments of either 110 or 220 lbs. until it reached 550 lbs., when the deflection at the end was 2·2 in. The load was then released to 0, and the set found to be 0·16 in. It was again applied and raised to 1,320 lbs., at which the deflection was 9·5 in. Upon release the set was 1·9 in. After raising the load to 1,694 lbs., where the deflection was 17·9, and again releasing, the set amounted to 8·3 in. The pole was finally broken under a load of 1,958 lbs., failure occurring at the base. The first small cracks were noted on the tension side under a load of 1,210 lbs., when the stress in the concrete was computed as 1,970 lbs. per sq. in., and in the steel 43,700 lbs.—*Engineering Record.*

CORRESPONDENCE.

Bosmere Bridge.—DEAR SIR,—As designers of the above structure, on which we notice a descriptive article in the last issue of your paper, we shall be glad if you will allow us space to make one or two points in connection with the design more clear to your readers.

The state of the existing abutments of the bridge was such that it was not considered prudent to allow them to take any of the weight either from the dead load or superload on the bridge. Two rows of Considere patent spirally armoured piles were therefore introduced, as shown in the photograph, and over these piles longitudinal girders were run, on which the positive and negative bending moments produced by the varying contingencies of loading were calculated. The bridge would therefore be perfectly stable even in the event of the existing abutments failing. We shall be glad if you will once again insert the photograph of the finished structure in order to make this explanation more clear.*—Yours faithfully,

CONSIDERE CONSTRUCTION CO., LTD.

The Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

TRADE NOTICES.

Designs and Tenders.—Mr. Vawdrey's paper at the Concrete Institute on the "Dissociation of Competitive Designs and Tenders" was a forcible expression of the somewhat unsatisfactory system under which designs and tenders for reinforced concrete work are at present submitted.

It must be granted, however, that the alternative system suggested by Mr. Vawdrey, under which the designs are examined on their merits and tenders called for on the selected design alone, is not without its disadvantages.

Amongst these may be mentioned the following :

1. The relative cost of any of the designs submitted is difficult to ascertain without obtaining tenders, and this point is certainly involved in deciding the relative merits of competitive designs.

2. The reinforced concrete specialist firms will in many cases have a greater

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*Owing to pressure of space we regret we are unable to insert the photograph, which appeared on page 388 of our May, 1911, issue.

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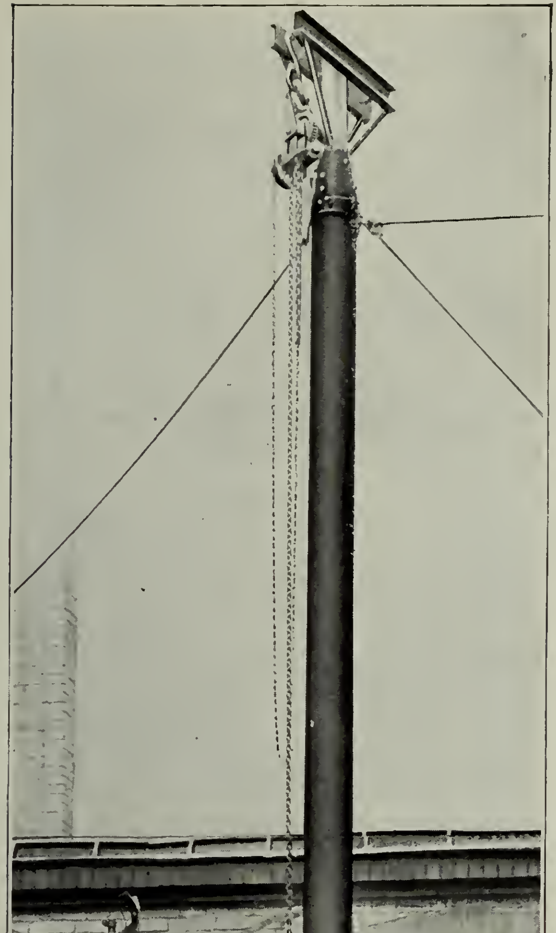
experience than the architect or engineer selecting the design, and this would, of course, be unsatisfactory to all parties.

3. Should the structure prove faulty, it is difficult to fix the responsibility as between the designer and the contractor, and this, without doubt, is one of the chief objections to this system, which may be described as one of divided responsibility.



It is therefore of particular interest to note that Messrs. Trollope & Colls, like several other notable contracting firms of old standing, are offering an alternative solution of the problem by moving in the opposite direction to that suggested by Mr. Vawdrey, and combining in the same firm both the designing and the construction of reinforced concrete work. Their engineering department, which will not be limited to reinforced concrete, will be at the firm's City office, 5 Coleman Street, E.C., and we understand that Mr. Oscar Faber, B.Sc. (Lond.), has been appointed as the engineer-in-charge.

Messrs. Trollope & Colls hope in this way to avoid any question of divided responsibility and much of the delay and trouble which now so frequently arises under the existing system.

Telescopic Mast and Hoist. — A device which should prove of considerable interest to engineers is being introduced in this country by the Comet Telescopic Mast Co., of 20 Bucklersbury, London, E.C. We understand that the mast has been approved by a number of foreign Governments for wireless telegraphy, searchlight, and observation work, and the manufacturers are now actively engaged in its application to a variety of industrial purposes. It is claimed that in building and constructional work the mast is especially adapted for use as a derrick or crane, and that it entirely dispenses with the use of light and heavy scaffolding for indoor and outdoor work.

Single tubular masts are constructed for loads of from three tons and upwards, while rectangular lattice masts may be made of a strength enabling them to carry a platform with cranes for serving the entire frontage of a building in course of erection.

There should be a good opening for an appliance of this description in connection with the maintenance and repair of overhead cables, electric lights, etc.

We are informed that designs are in course of preparation for a special type of telegraph pole which will dispense with the use of a derrick, the pole being thrust upwards in the same manner as the mast and afterwards clamped in position. If practicable, this should prove a novel and useful departure in this class of work.

The mechanism is extremely simple and reliable. The telescopic tube is raised by means of a strong perforated steel band, which occupies the full section of each tube in such a manner that it cannot buckle, and acts as a rigid piston to push or thrust its load upwards. The steel band, which is served from a drum by means of a winch and toothed rollers engaging its perforations, acts in conjunction with an automatic locking device which locks each section in position so that the mast may remain raised, even though the band is withdrawn. Numerous other uses of the mast, such as for hoists, lifts, etc., will occur to the expert.

The British Reinforced Concrete Engineering Co., Ltd.—We hear that the British Reinforced Concrete Engineering Co., Ltd., of 196 Deansgate, Manchester, are launching out in a much larger way to meet the demands for their system.

A recent meeting of shareholders unanimously sanctioned a large increase of capital, warranted by dividends and profits on works in hand. The secretary reported the acceptance of several important contracts in Britain and a large increase of foreign orders.

EDITORIAL MEMOS.

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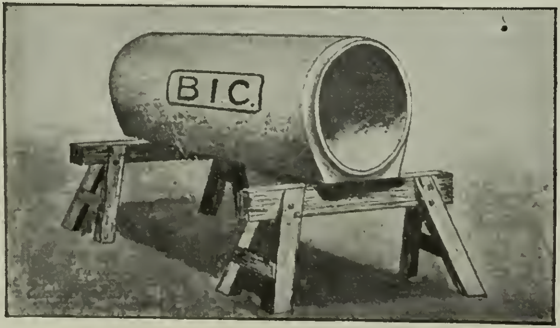

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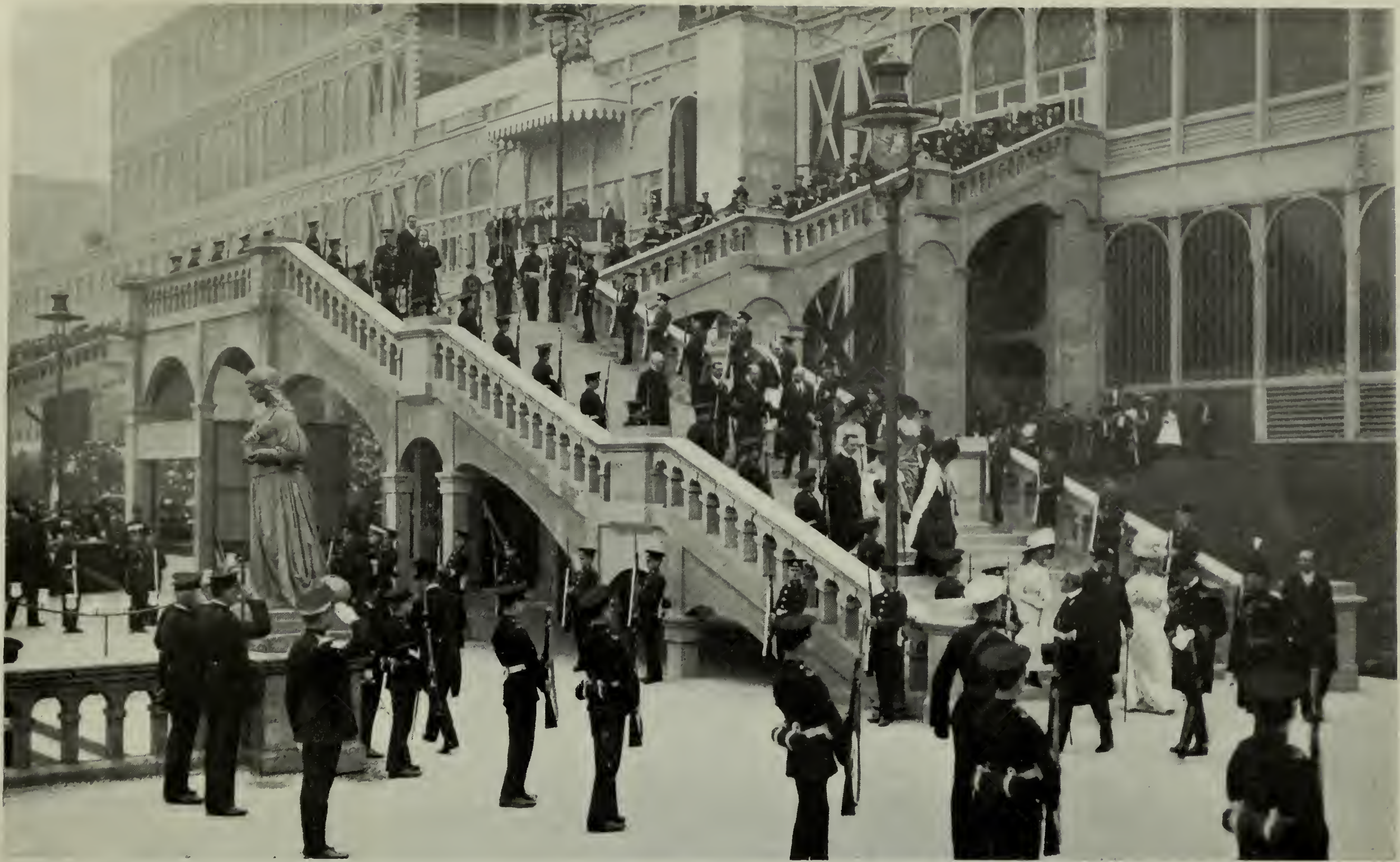

Their Majesties the King and Queen descending the Stairs.

Reinforced Concrete Staircase at the Festival of Empire.

(This staircase was made by the Empire Ston Co. from the designs of Mr. Burnard Geen, A.M.Inst.C.E.)

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume VI. No. 7. LONDON, JULY, 1911.

EDITORIAL NOTES.

THE CONCRETE INSTITUTE.

THE first annual summer meeting of the Concrete Institute, which was held during the past month, marked another stage in the development of this newly-formed body. Under the presidency of Sir Henry Tanner, C.B., the technical proceedings were conducted on the two forenoons of June 7th and 8th. The afternoons in each case were occupied by visiting works of interest and the evenings were devoted to social functions—*i.e.*, to a dinner on the first day and a conversazione on the second.

Though the technical proceedings were not as well attended as we should have expected, having regard to a membership that now touches close upon a thousand, a large attendance could perhaps scarcely be expected with the holiday feeling of an impending Coronation in the air and the hot weather that pervaded at the time. But if the working part of the programme was somewhat neglected, the social side found great favour, and we think that this beginning of such functions is a step in the right direction, and will eventually do wonders towards welding together the somewhat diverse character of the membership, and give to the Institute that *esprit de corps* which is absolutely essential to an institution of this character, and which is yet sadly lacking.

THE IMPORTANCE OF SOCIAL ENTERTAINMENTS.

It may seem strange to emphasise in a technical journal the importance of these social entertainments, but where, as in the case of the Concrete Institute, the interests of the professions and industries concerned easily clash, it is of the utmost importance that the representatives of those different spheres of work should obtain a better understanding of the characteristics and personal views of the individuals with whom they have to come into contact. Apart from this personal element, there must be an obvious advantage in the representatives of the professions and industries concerned meeting on neutral ground and taking the opportunity of discussing technical points and exchanging ideas and experience, which it is generally difficult for them to do in their ordinary relationship.

NOTABLE GUESTS AT THE INSTITUTE DINNER.

The Institute, in inaugurating this new departure, was particularly fortunate in having a president who is personally popular, and who at the same time understands thoroughly the characteristics of the different sections of the membership, which, apart from being divided into the two great classes of the professions and industries concerned, is further subdivided into (*a*) specialists, (*b*) contractors, and (*c*) manufacturers, on the industrial side ; and into (*a*) civil engineers, (*b*) architects, and (*c*) scientists, as far as the larger professional section is considered.

At the inaugural dinner this diverse character of the Institute was not only observable among the members, but also among the guests, and it promised well that so representative a body of men should meet at the Institute's festive board. Notable among the guests present we observed the President of the Institution of Civil Engineers (Mr. Alexander Siemens), the President of the Royal Sanitary Institute (Mr. H. Percy Boulnois), the President of the Surveyors' Institution (Mr. W. Edgar Horne), and the Past-President of that body, Sir Alexander Stenning ; architects so well known as Mr. John Murray, F.R.I.B.A. (the Crown Surveyor), and Mr. William Woodward, F.R.I.B.A. (the Mayor of Hampstead) ; while practical scientific research had as its deputy Mr. Leslie Robertson, M.Inst.C.E. (of the Engineering Standards Committee). Mr. F. A. White (the chairman of the Associated Portland Cement Manufacturers, Ltd.) was a guest, representative of the great manufacturing interests.

As to the members present, it would lead too far to give lists of names, but besides the President, two Vice-Presidents (Mr. Alexander Ross, M.Inst.C.E., and Mr. Edwin O. Sachs, F.R.S. Ed.) were present, as also Mr. E. P. Wells (the Chairman of the Finance Sub-Committee).

THE CONCRETE INSTITUTE AND THE INSTITUTION OF CIVIL ENGINEERS.

It must have been gratifying both to the membership and to the President of the Institute that the guests were of so representative a character, and that the great mother, or, as it was jocularly described, " grandmother " of technical institutions—namely, the Institution of Civil Engineers, was represented by its head. There is no doubt that if the younger body—namely, the Concrete Institute—of which a large proportion of members are associated with the engineering profession, would co-operate with the senior institution of Great George Street, this would be beneficial to both bodies ; and seeing that the younger Institute has already shown its ability and strength to stand on its own feet entirely if necessary, there is no fear of its either being overawed by the senior body, or falling into its errors of ultra conservatism regarding the subject of reinforced concrete.

As in the past, when co-operation was absent, the activity of the Concrete Institute will, when it is in closer touch with the Institute of Civil Engineers, probably lead to a more rapid development in the efforts of the latter body to make up for leeway lost in the investigation of the problems of reinforced concrete. If the mere fact of the Concrete Institute's being formed actually resulted in the Great George Street institution having its own reinforced concrete committee, it would almost be a certainty that a little assistance and kindly reminder from the junior body will lead to that committee accelerating its pace, and, above all, promptly putting some of the much-required testing operations in hand.

At all events, the presence of Mr. Siemens at the Concrete Institute speaks well for the future, for the Institute can now no longer be looked upon as an intruder among its seniors of Westminster fame.

THE PAPERS AND REPORTS.

The subjects before the summer meeting comprised two papers, one by Professor Beresford Pite. F.R.I.B.A.,on "The Æsthetic Treatment of Concrete," and the other by Mr. A. E. Corbett, F.R.I.B.A., on "The Y.M.C.A. Building, Manchester." Besides these, two reports were put forward for discussion—namely, "The Interim Report of the Tests Standing Committee on the Testing of Concrete, Reinforced Concrete, and Materials Employed Therein"; and "Report of the Reinforced Concrete Practice Committee, embodying suggestions on the standardisation of drawings of Reinforced Concrete Work."

This programme of work was excellent, but unfortunately the attendance was not as strong at these technical meetings as could have been desired, yet the discussion of the papers was exceptionally good, and that on Professor Beresford Pite's paper, which was of an exceptionally high standard, is to be further discussed at an ordinary meeting of the Institute in the winter, and we look forward to some distinguished architects and engineers being invited to give their views on the subject.

As for the reports of the two committees, the discussion on these had also to be postponed, and in our opinion these reports require thrashing out at the ordinary meetings in order that really good results may be obtained. We would suggest that the papers which are in print should be issued to the whole of the membership, and the opinion of those distant from London be invited by correspondence, which might be presented at the meetings. There is not the least doubt that in some of these questions the experience of the Provincial and Colonial members would be particularly valuable.

It should perhaps be mentioned that, so far as the report on "The Standardisation of Drawings of Reinforced Concrete Work" is concerned, it bears a marked similarity to the proposals put forward in these columns by Mr. H. Kempton Dyson in our issue of February, 1910, and which should be referred to by our readers. Again, regarding the suggestions of the Tests Standing Committee, we would suggest reference to a report of a Special Commission on Concrete Aggregates, appointed by the British Fire-Prevention Committee, which was published in our issue of January, 1909.

THE VISITS.

The programme of visits was excellent, but here again the attendance was not as large as might have been anticipated from the instructive character of the work to be shown; but, nevertheless, those who had the arrangements in hand should not be discouraged, as circumstances were very much against the meetings, and we think that further inspections of this kind should be arranged for. The buildings visited were the Wesleyan Hall, Westminster, described in our issue of October, 1910, and a wharf and warehouse now being constructed of reinforced concrete piles, floors, and walls in London Dock.

THE INSTITUTE'S PAST YEAR OF WORK.

The summer meeting, to which we here refer, practically served to mark the termination of the past year's work, and we therefore take this opportunity of referring to the annual report of the Institute, and we think it would be well in this connection to quote from it at some length, as the report gives a very excellent idea of the character of the work which is to be done.

> ***Legislation.***—The Council has had under consideration a Draft of Suggested Regulations to be made under the provisions of Section 23 of the London County Council (General Powers) Act, 1909, with respect to the construction of buildings wholly or partly of reinforced concrete. These regulations were submitted by the Superintending Architect of the London County Council to the Institute for its consideration in accordance with the provisions of the 1909 Act referred to, whereby it is enacted that the Concrete Institute, together with the Institution of Civil Engineers, the Royal Institute of British Architects, and the Surveyors' Institution are to have notice of the Council's intention to apply to the Local Government Board for allowance of any regulations as to the use of reinforced concrete in the County of London. In connection with this the Royal Institute of British Architects convened a meeting of representatives of various technical societies interested in the matter, and Mr. Charles F. Marsh, M.Inst.C.E., and Mr. T. B. Shore were appointed as the delegates of the Concrete Institute. This Conference of Societies held a number of meetings, and recommendations were arrived at which were transmitted by the Royal Institute of British Architects to the London County Council. The Science and the Reinforced Concrete Practice Standing Committees of the Concrete Institute held six joint meetings, at which were drawn up a number of recommendations for the amendment of the Draft Regulations. These suggested amendments were put forward by the Institute's delegates at the Conference of Societies. The Council transmitted to the Superintending Architect the proposed amendments arrived at by the Joint Committee of the Concrete Institute, and informed him that the Institute was in substantial agreement with the recommendations of the Conference of Societies, but would be glad if the London County Council would also consider the further suggestions contained in their Joint Committee's amendments. The matter is at present confidential, as the Draft Regulations submitted were merely in a preliminary stage ; the Council is therefore unable to furnish detailed particulars of the recommendations made to the London County Council.
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> ***By-laws for Reinforced Concrete.***—With a view to the removal of restrictions in the building by-laws in respect to the construction of reinforced concrete and the short loan periods granted by the Local Government Board on structures of such material, the Parliamentary Committee has been in communication with the Board in reference to by-laws respecting reinforced concrete construction and walls of new buildings, and the reply, dated December 8th, 1909, stated—
>
> " The Board are only aware of one authority, the Urban District Council of Newquay, Cornwall, who have in force by-laws specifically dealing, except in connection with steel framing, with the construction of buildings of ferro-concrete. The Board confirmed a series of by-laws for that authority on October 22nd, 1909, which has the effect of allowing the walls of new buildings to be constructed of reinforced concrete of such thickness as shall be necessary to secure due stability. Some local authorities, including the Town Councils of Leeds, Salford, and Windsor and the Urban District Councils of Brentford, King's Norton, and Northfield, Penge, and Southall Norwood, have made by-laws allowing the construction of buildings of steel framing filled in with brick or other incombustible material, which, of course, includes ferro-concrete. . . . . In a large number of rural districts in the country either there are no by-laws in force regulating buildings or the by-laws are based on the Board's rural code, which makes no provision as to the structure of walls for securing stability or the prevention of fires. In such districts the construction of buildings of ferro-concrete would be unrestricted. In many other districts a by-law has been adopted similar to that numbered 4 in the Board's provisional Intermediate Model which allows the erection of domestic buildings, subject to certain conditions as to size and position, of other material than brick or stone. The use of ferro-concrete would thus be permitted in the construction of such buildings. The Board may

say that they have not found that a large number of local authorities have expressed a wish to make provision in their by-laws for the use of ferro-concrete. They will, however, bear in mind the question of regulating its use in any future edition of the urban model code which they may issue."

Engineering Standards.—The Engineering Standards Committee asked the Concrete Institute to appoint a representative on their Sectional Committee on Portland Cement, and the Council in May appointed Mr. Herbert W. Anderson, Assoc.M.Inst.C.E., to act in that capacity.

The Engineering Standards Committee at a later date asked the Institute to appoint a representative on their Sectional Committee on Bridges and Building Construction, which deals with the standard specification for steel, and Mr. William G. Kirkaldy, Assoc.M.Inst.C.E., was appointed by the Council.

Reinforced Concrete Practice Committee.—The Royal Institute of British Architects asked the Concrete Institute to appoint two representatives on the Joint Committee on Reinforced Concrete, and the Council appointed Mr. William G. Kirkaldy, Assoc.M.Inst.C.E., and Mr. Charles F. Marsh, M.Inst.C.E., to act in that capacity.

New Appointments.—The Earl of Plymouth having retired from the office of President, Sir Henry Tanner was appointed to that position, and Mr. Alexander Ross was appointed a vice-president to fill the vacancy created by Sir Henry Tanner's acceptance of the Presidency. The Council also appointed Mr. Edwin O. Sachs, the former Chairman of the Executive, as a fifth vice-president. The Council desire to record their appreciation of the great services rendered by Mr. Edwin O. Sachs in the formation of the Institute.

When the new Rules came into force the Finance Committee was appointed, consisting of Mr. E. P. Wells, the former Honorary Treasurer, as Chairman, and Mr. W. T. Hatch, Mr. Alexander Ross, Mr. Edwin O. Sachs, Mr. L. Serraillier, and Sir Henry Tanner as members.

Medal for Papers.—A medal will be granted for the best paper read at general meetings in each session, it being thought that this should encourage the contribution of data that would prove of service to members, particularly when recorded in the " Transactions."

Standard Notation.—The Standard Notation for calculations for reinforced concrete which was drafted by the Science Committee and approved by the Council has been favourably received, and will in all probability be adopted by the Joint Committee on Reinforced Concrete, appointed by the Royal Institute of British Architects, in their revision of the report first issued by them in 1907, and by the London County Council in their regulations governing the erection of reinforced concrete structures in London. It has also been adopted by the authors of text-books, and is to be considered by the American Joint Committee on Concrete and Reinforced Concrete. It therefore promises to be of considerable utility.

Since the publication of the annual report the result of the elections for the year 1911–12 has also been made known, and we have been informed that the new members of Council are as follows :

Captain J. Gibson Fleming,* R.E., Messrs. J. Ernest Franck,* A.R.I.B.A., C. S. Meik,* M.Inst.C.E., W. G. Perkins*, Henry Tanner* (Jr.), F.R.I.B.A., and G. C. Workman.

FUTURE WORK.

After dealing at such length with the work of the Concrete Institute, it only remains for us to wish that body every success in the future, which we feel will, no doubt, be attained under its new President, Sir Henry Tanner, C.B., and its strengthened Council, particularly if the latter will show that assiduity in work which is absolutely essential for a newly-formed Institution. Election on the Council is not only a distinction, but brings with it obligations, and it would be advisable in future if all those who are so closely identified by name with this Institution were to put in a stronger appearance at its business meetings, lectures, and its social functions, so that those duties be not left, as would appear to be the case very frequently at present, to a limited few. Good service on the Standing Committees should mean future advancement to the Council, and the idea of electing the Vice-Presidents from the Council is also a step in the right direction.

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* Newly elected to the Council on this occasion.

As to the direction we hope the work will take, we trust that the civil engineering, architectural, and the industrial side will be accorded equal importance, and that every possible effort will be made to improve the conditions under which reinforced concrete is executed, which is still greatly hampered by legislative hindrances and conservatism.

THE STORAGE OF CEMENT.

UNDER this heading last month we referred to the aeration of cement on the works that is still favoured by many engineers and architects.

Such aeration or air slaking was advisable years ago with cements as then manufactured, which were coarsely ground and often underburnt, and consequently liable to blow or expand, perhaps resulting in disintegration of the concrete, or incidental troubles in the way of expansion ; but with modern Portland cement manufactured under skilled chemical control and greatly improved conditions generally, such aeration is not only unnecessary and an antiquated relic of the past, but is positively injurious to the strength of concrete made therewith. Cement is valuable as a constructional material by reason of its property of being able to combine chemically with a certain amount of water to form a hard and compact mass. The finer cement is ground, the more chemically active it is ; consequently, when the finely ground cement that is at present called for is exposed to the atmosphere it absorbs moisture with avidity. This water combines with the silicates and aluminates, liberating calcium hydrate (the same substance as slaked lime); this calcium hydrate in turn absorbs carbonic acid gas (carbon dioxide) from the air, and becomes converted into calcium carbonate (the same substance as chalk). In this way a portion of the cement is rendered inert, and if this natural process of hydration by contact with the atmosphere be continued for a sufficient length of time, the whole of the material will be gradually killed, and will cease to have any value. It has been shown in numerous experiments that exposure in thin layers in moist atmosphere for three or four months is sufficient to render cement useless for constructional purposes ; it therefore follows that if such excessive aeration is entirely destructive of the cementitious value, partial aeration will deteriorate it exactly in proportion to the comparative duration of time of exposure ; it is simply a question of degree. The coarse, imperfectly calcined cements of the past were not subject to such marked deterioration because of their lesser chemical activity, and, moreover, and quite apart from that, any deterioration from such a cause was far less serious compared with the advantages derived by having a sound cement or freedom from tendency to expand in the work.

One point that is often urged in favour of aeration is that the setting time was increased—that is to say, that cements were by such treatment rendered slower setting. Though that was undoubtedly the case with coarsely-ground cements, the same argument does not apply to modern cement, and it is a particularly crude and haphazard method of endeavouring to regulate the setting time, although the absorption of moisture tends to lengthen the setting time. On the other hand, the absorption of carbonic acid gas tends to result in a quickening of the setting time: and as both moisture and carbon dioxide are present in the air, the effect of the aeration as regards setting time will be dependent on the relative amount of each of these substances absorbed by the cement. This relative amount is dependent upon local conditions, and therefore the setting time of modern cement thus aerated may be, and often is, rendered quicker instead of being retarded; indeed, the adoption of the process of aeration is decidedly objectionable from all points of view, and its continued adoption is unjustifiable, and can only be attributable to ignorance.

In the patented process of cement manufacture, whereby steam is admitted to the tube mill in the process of fine grinding, the cement is scientifically matured, and its setting time regulated with accuracy. In this process the particles of cement are surrounded with an atmosphere of steam during their attrition and pulverisation, thus every particle of the cement is enabled to absorb and combine with a regulated quantity of water in the absence of carbon dioxide, which latter, as has been shown above, renders cement inert—and that is far from what happens by this steaming in the process of grinding. Cement is now supplied to pass the test given in the British Standard Specification without any treatment on the works, and as these tests are passed satisfactorily, there need be not the slightest hesitation on the part of any engineer, architect, or contractor in using the cement direct from the sacks or casks without any laying out or turning whatever.

OBITUARY NOTICE.

THE LATE DR. WILHELM MICHAELIS.

During the month of May there passed away one of the most prominent figures in the world of cement technology in the person of Professor Dr. Wilhelm Michaelis, of Berlin. To everyone concerned in the production of Portland cement his name was a household word, and he did perhaps more than any other man to advance our scientific knowledge in connection with this material.

He was born in Magdeburg on October 15th, 1840, and was therefore in his seventy-first year at the time of his death.

For years he conducted a laboratory in Berlin, which was at one time or other the resort of most of the German cement manufacturers as well as of those of other nationalities. It was the scene of an immense amount of research work into the many mysteries which are associated with the production and the behaviour of Portland and other cements, and from the active management of this laboratory he only retired quite recently. After retirement he still retained the keenest interest in everything associated with cement, whether it happened to be Portland cement or any other material capable of being used for similar purposes.

One of his last public efforts was the enunciation of what he called the "Gel" theory of the setting of Portland cement. His opinions on this matter were embodied in a paper which he read before the annual meeting of the German Association of Portland Cement Manufacturers two years ago, in which he claimed to have settled definitely and finally the nature of the chemical processes involved in the setting and hardening of Portland cement. That his opinions on this point were not shared by every other expert is hardly surprising, but he advocated them with all the energy and persistence so characteristic of his nature, and time alone will show how far his theory is maintainable.

For some time past he had been suffering from an ossification of the arteries, and had become subject to fainting fits, one of which was the cause of his death. On the last occasion he was seized by one of these when looking out of the window of his flat, and he fell outwards to the ground with fatal results. The end was tragic in its nature and in its suddenness, and the world of science is the poorer for his loss.

The late Professor W. Michaelis.

THE FIRST SUMMER MEETING OF THE CONCRETE INSTITUTE.

Having regard to the importance of the subjects dealt with at the Summer Meeting of the Concrete Institute, we are making a feature, in the current issue, of the proceedings at this meeting. If this occupies somewhat more space than we generally accord to the Concrete Institute in any one number, we think that, by the diversity and interest of the subjects treated, the occasion merits a prominent place in our Journal.—ED.

THE two days' Summer Meeting of the Concrete Institute was held on Wednesday and Thursday, June 7th and 8th. On the morning of June 7th a meeting took place in the Lecture Hall of the Institute at Denison House, Vauxhall Bridge Road, Westminster, Sir Henry Tanner, C.B., in the chair, when a paper was read by Professor Beresford Pite, F.R.I.B.A., on the " Æsthetic Treatment of Concrete." A discussion followed, in which Messrs. Heathcote Statham, F.R.I.B.A., A. Alban H. Scott, M.S.A., Edwin O. Sachs, F.R.S.(Ed), J. Ernest Franck, A.R.I.B.A., C. H. Colson, M.Inst.C.E., A. E. Corbett, F.R.I.B.A., Percival M. Fraser and the President took part. An Interim Report of the Tests Standing Committee on " The Testing of Concrete, Reinforced Concrete, and Materials employed therein " was then presented, and discussion thereon was deferred until next session.

In the afternoon a visit was paid by the kind permission of the architects, Messrs. Lanchester and Rickards, FF.R.I.B.A., to the Wesleyan Memorial Hall, Tothill Street, Westminster, now in course of construction, and in large part of reinforced concrete.

In the evening the first Annual Dinner of the Concrete Institute was held at the Trocadero Restaurant, Shaftesbury Avenue, Piccadilly Circus, W., the members being received by the President, Sir Henry Tanner, C.B. Among other guests of the Institute were the following : Mr. Alexander Siemens, President of the Institution of Civil Engineers ; Mr. W. Edgar Horne, President Surveyor's Institution ; Mr. H. Percy Boulnois, M.Inst.C.E., Chairman of the Council of the Royal Sanitary Institute ; Mr. R. Elliott Cooper, V.P.Inst.C.E., the Chairman of one of the Sections of the Engineering Standards' Committee ; Mr. Leslie H. Robertson, the Secretary of the same Committee; others present were Mr. Horace Porter, A.R.I.B.A., Mayor of Holborn ; Mr. W. Woodward, F.R.I.B.A., Mayor of Hampstead ; Sir Alexander Stenning ; Mr. John Murray, F.R.I.B.A. ; Mr. Osborne Smith ; Mr. F. A. White, late Chairman of the Associated Portland Cement Manufacturers, Ltd. ; Mr. Max Clarke, F.R.I.B.A., late Mayor of Holborn ; Mr. Edwin T. Hall, Vice-President R.I.B.A. ; and the following members of Council of the Concrete Institute : Mr. Alexander Ross, M.Inst.C.E., Vice-President Concrete Institute ; Mr. Edwin O. Sachs, F.R.S.(Ed.), Vice-President Concrete Institute ; Mr. D. B. Butler, Assoc.M.Inst.C.E., Mr. C. H. Colson, M.Inst.C.E., Mr. J. S. E. de Vesian, M.Inst.C.E., Mr. William Dunn, F.R.I.B.A., Mr. E. Fiander Etchells, F.Phys.Soc., Mr. J. Ernest Franck, A.R.I.B.A., Mr. C. S. Meik, M.Inst.C.E., Mr. H. D. Searles-Wood, F.R.I.B.A., Mr. Henry Tanner (Jr.), F.R.I.B.A., Mr. E. P. Wells, J.P., Mr. F. E. Wentworth Sheilds, M.Inst.C.E., and Mr. G. C. Workman.

After the patriotic toast from the Chair, Mr. Alexander Siemens, President Inst.C.E., proposed the toast of the Concrete Institute, and said :—

> Gentlemen, when your President asked me about a fortnight ago to give the toast of the Concrete Institute I accepted the suggestion with a light heart, but when I began to consider what I ought to say, my spirits fell, because there are some difficulties in the way. One is that our Institution, the Institution of Civil Engineers, has got a little concrete institute of its own (laughter), and I have to balance my remarks so that I give due place to the present Concrete Institute without offending our own. But I think after all the matter is not so serious as it might at first appear, because as soon as I came into the room I shook hands with Mr. Bamber, and you know that Mr. Bamber read a paper before the Institution of Civil Engineers in November, and there was a grand discussion on the subject of concrete, which I think is nearest to your heart. That paper shows that the Institution of Civil Engineers considers itself the grandmother of all engineering institutions. I say deliberately grandmother, because there are some institutions who try to teach us how to suck eggs. But we are accustomed to that, and we welcome it because you see this is your first dinner and you therefore acknowledge that you are a young institution. I want to say on behalf of the Civil Engineers that we are very glad of every new development of engineering science in the application of the objects for which the Institution of Civil Engineers was founded, and for which it received its charter. Every new institution which pursues a specific object helps the parent institution, because with the modern applications of science which are directed by the engineers in the various branches it is perfectly impossible that one institution should do justice to all, and therefore all these special institutions are really of assistance to the great profession of engineering. Your Institution has been—I must not use any physiological expression, I suppose—in the making for nearly four years, but it really took shape and came into proper existence last year, when your present constitution was worked out by the Council and adopted by the Institution, and when Sir Henry Tanner became its President. Of course we must not forget that the Earl of Plymouth as the first President of the Institute and Mr. Sachs as Chairman had a great deal to do in working up the Society, but all the same the present constitution of the Society really dates from last year. It is a matter of great congratulation to its members that you are nearly a thousand strong already, and it is therefore with great confidence that I propose the health of the Concrete Institute and wish it a prosperous career. The Institute has already shown its usefulness by its delegates joining some committees of the Engineering Standards Committee. That shows that it fills a place which was vacant before, and that it has a useful purpose in the scheme of engineering things. I therefore ask you to drink success to the Concrete Institute and couple with the toast the name of your President, Sir Henry Tanner.

The toast was responded to by Sir Henry Tanner :—

I thank you, sir, for the kind words with which you have proposed this toast of the Institute coupled, and also you, gentlemen, for the manner in which you have received the toast. It seems to me that co-operation between ourselves and the Institution of Civil Engineers is what we ought to desire. It will certainly forward our objects, and it will be to the interests of the members of the Institution of Civil Engineers without a doubt. We were only founded, as Mr. Siemens said, about 3½ years ago, and the first part of that time the Institute was in an embryo condition and we did not quite know where we were, but last year we spent our time in re-organising and this year in looking out for offices and establishing ourselves in them. We have done these things now, so that we anticipate that we ought to be able to devote more time and attention to those things which are more appropriate to the Institute, and I hope that will be done. We number 960 now, and that surely shows that the objects of our Institute are of considerable interest to a great number of people. Increased interest is being shown in concrete because of the enormous amount of literature which is now published, and we have got practically a journal to ourselves in the "Concrete" Journal, which devotes itself mainly to the objects of our Institute. We have got a certain amount of influence already. We have been consulted among others with regard to the regulations which the L.C.C. propose to adopt for the use of reinforced concrete, and we hope the matter will not end there, but that the Local Government Board will adopt them in its model by-laws, and that they will become a general thing. In the last few days we have been told that the Local Government Board has granted a loan on the basis of 30 years for reinforced concrete. That is quite new. Hitherto it has been 15 years, and I think we may take some credit to ourselves that it has gone up to 30 years. It may go to more still and be put on the basis of ordinary construction. Our committees have been doing a certain amount of good work. They have drawn up a notation for calculations which bids fair to be adopted by all English-speaking countries which adopt reinforced concrete. They have also had a rather extended inquiry into rust on steel in concrete, not because it was needed, but to set people's minds at rest as to what happens. The result seems to have been entirely satisfactory so far as one knows. Then this morning we presented a report on testing. There was nothing said about that report, and it was left to future argument because nobody had had time to consider it. Then to-morrow there is to be a similar report on standardisation of drawings. All these things are making for the regularisation of reinforced concrete. Both Portland cement and reinforced concrete were invented in this country. Portland cement we have always taken the lead in manufacturing, but the other half of the business was left to the foreigner, and he really brought it to a stage of some regularity and standardisation. But now that we have got extremely good cement we seem to have taken up reinforcement with considerable energy, and within the last four or five years it has grown enormously in use in this country, and is likely to grow more. Of course we claim for it that it is simplicity itself so far as materials are concerned. You can get round bars almost anywhere, and you can get the necessary materials for the concrete. Then in regard to fire there is nothing to beat it. Its durability is without doubt and its economy in regard to repairs is beyond question. I think we might even get the Mayor of Hampstead sooner or later to come to our side and not to condemn us altogether. I am not proposing to keep you any longer. I think I have said quite enough to justify our existence.

The toast of the visitors was proposed by Mr. Edwin O. Sachs. He said :—

Mr. President and gentlemen, I am very pleased to have this toast placed in my hands. I am a great believer in hospitality, and it is delightful that this Institute at its first dinner should be able to receive not only guests, but distinguished guests. We are naturally pleased to see Mr. Siemens here. Mr. Siemens has been a popular figure among the technical profession for many years. We meet him on all manner of occasions where there is good work to be done—be it at the Royal Society of Arts, the Institution of Civil Engineers, the Institution of Mechanical Engineers, the British Fire Prevention Committee, or what not. Everywhere he is welcome. This evening, gentlemen, we see him here as President of the Institution of Civil Engineers, and we are proud to welcome him in that capacity. Mr. Siemens has spoken in that capacity and has given us a gentle hint that children should not " teach their grandmothers to suck eggs." Well, gentlemen, grandmothers of old had curious ways of dressing. They did not know the modern corset. When we started the Concrete Institute we thought the modern stay, with its reinforcement, was wanted, and we found after it had been started for a year or two that the Institution of Civil Engineers was similarly suddenly interested in this modern development, and formed a miniature concrete institute of its own. We wonder if that little concrete committee of the Institution of Civil Engineers would have come to life at all if this Institute had not first made its appearance with something like four hundred of the old institution's members? We congratulate the Institution of Civil Engineers on the good work it has now done in that direction during the last two years, and if this Institute is able to help the Institution of Civil Engineers and kindred societies on the Engineering Standards Committee we are proud of it. When forming this Institute we were naturally guided by precedent, and a remark made by Mr. Siemens that we had first had a titular President, a distinguished earl, to whom we were very much obliged for coming forward and helping us and lending us the prestige and power of his name when we were a small body of 100, makes me remark that we were entirely orthodox in that matter. If Mr. Siemens will turn back to the history of the Iron and Steel Institute, that body had exactly the same experience, and commenced, if I rightly remember, also with a titular President. I am not quite sure whether it was the Duke of Devonshire or the Earl of Derby, but it was one of the two, I believe (Mr. Siemens : The Duke of Devonshire). Following the example of an institute so closely allied with the Institution of Civil Engineers, and one in which Mr. Siemens is a notable figure, we also commenced operations with a member of the House of Lords as President. We are a rather small party here, but we represent, as Sir Henry Tanner has said, a membership of 960, and that for a child of but a few years is, I think, quite a nice record. This evening we not only have the Institution of Civil Engineers represented by its President, but we are delighted also to see here the President of the Surveyors' Institution, Mr. Horne, and with his predecessor who has done much good work in the interests of civil engineering quite as much as surveying ; Sir Alexander Stenning is also at our table. It would perhaps go too far if I ran through the rest of our guests ; but I think I should mention Mr. John Murray, that most popular architect who represents the Crown, and our special friend the Mayor of Hampstead, whom we hope some day to see a member of our body, and another architect, the Mayor of Holborn. Well, gentlemen, we have the professions of architecture and civil engineering duly represented, and architecture, too, in its civic capacity as representing two great boroughs in this great City. One guest I have not mentioned.

and on him I am going to place the ordeal of responding to this toast, and that is Mr. Percy Boulnois. We all remember him at the Local Government Board, which I believe he has now just left, but he is still actively interested in all things technical, and this year is chairman of the Sanitary Institute, which does excellent service to the country. Gentlemen, I give you the toast of "The Visitors." We are proud to see them, and we drink their health most heartily.

Mr. H. Percy Boulnois, in replying to the toast, said :—

I must confess in this distinguished company that I was astonished that I should be called upon to reply to this toast. It could not be because I am chairman of the Royal Sanitary Institute, because that Institute has very little to do with concrete, but it has to do with a vast number of subjects, and embraces a great number of members of all professions —engineers, architects, and medical men. Then I don't think I was called upon to reply to this toast because of my personal qualifications. So I came to the conclusion that I was called upon to reply to this toast because I happened to have served for some years with that bogey, if I may be allowed to so call it, the Local Government Board. I call it a bogey because, as you know, for many years the Local Government Board have been obliged necessarily to be cautious as to what they did with regard to ferro-concrete or reinforced concrete, or what you please to call it, and I think they acted perfectly wisely, because it was a new thing in this country, and we were more or less the custodians of the public purse, and we wished to go cautiously. But, on the other hand, we must remember that engineering is bound to advance, and must make progress and take new things in hand. Otherwise we should not be here to-night. We should be cave-dwellers throwing bones at each other. It is a little difficult for me to know what is in the minds of the clients I represent—viz., the guests. All I know is that I am sure I echo their feelings when I say we have enjoyed an excellent dinner. I feel almost that we guests are a sort of committee. We have been testing various materials. We have been taking in an aggregate. Whether that aggregate we have taken in will cause some undue stress on our middle third I really don't know. All I know is we have saturated ourselves with liquid, and whether that will interfere with our modulus of elasticity I am not quite sure at this moment. What I feel is that after this hospitable board, if we can seek our homes without indenting our footsteps or taking a zig-zag course, we might reach our homes and go to our beds and become sound sleepers. It is a great privilege to be here to-night, because it is the first dinner of this young Institute. Personally, on behalf of myself and the guests, I wish you every success. I am certain that success is assured you. You have done good work, and there is an immense amount of work before you. I thank you heartily for having received us here to-night.

On the morning of Thursday, June 8th, a meeting took place in the Lecture Hall of the Institute at Denison House, Westminster, Mr. E. P. Wells, J.P., in the chair, when a paper was read by Mr. Alfred E. Corbett, F.R.I.B.A., on the "Y.M.C.A. Building at Manchester." We give a *résumé* of the paper and of the discussion which followed in this article.

The Report of the Reinforced Concrete Practice Standing Committee on the "Standardisation of Drawings of Reinforced Concrete Work" was then presented. The discussion thereon was deferred until next session.

In the afternoon a visit was paid, by kind permission of Mr. Frederick

Palmer, C.I.E., M.Inst.C.E., Engineer to the Port of London Commissioners, to inspect a wharf and warehouse now being constructed of reinforced concrete piles, floors, and walls, in London Dock,

In the evening a *conversazione* was held in the galleries of the Royal Institute of British Architects, Conduit Street. Members were received by the President, Sir Henry Tanner.

THE PAPERS.

THE ÆSTHETIC TREATMENT OF CONCRETE.

By PROFESSOR BERESFORD PITE, F.R.I.B.A.

This was a most important and interesting paper which really requires an exhaustive extract, but the one provided to the Press on this particular occasion gives no adequate idea of the excellence and utility of the paper in question. We publish the official extract as it was sent to us, and we trust that what is unfortunately lacking in clearness in this extract may be made up for in part by the lengthy summary of the discussion which we give below.

We take this opportunity of suggesting that the Institute should follow the example of some of the leading technical societies by sending a copy of the paper to the Press and allowing them to publish their own extract—limited, of course, to a certain number of words—so that the Press could then give their readers an extract of the particular portions dealing with their special interests.

The following are summaries of the paper and discussion.

Simplicity of intention in constructional design may issue in a native or spontaneous æsthetic quality. An undesigned beauty reached without treatment is often attained by such a structure as the Forth Bridge or a reinforced-concrete silo. Mediæval architecture grew up as a constructive method without æsthetic purpose and achieved results of great beauty. Is not the opportunity given by the new process of reinforced concrete building one that could be utilised for the erection of the much-desired original and modern style of architecture? Are the new material and method together sufficient motive? Truthfulness of design to constructive purpose and elemental soundness of proportion, are these sufficient to provide that pleasantness to the eye which is desiderated?

Four conclusions arrived at (1) we have no instinctive guidance towards an unbiassed originality for a concrete architecture; (2) Abstract principles like those invoked of proportion are of no assistance; (3) Superficial treatments, as by colour, are insufficient for architectural expression, though valuable in assistance; (4) The texture of concrete surfaces modifies and imparts special character to any forms employed for architectural purposes. Therefore, while modern considerations of utility and of novel constructional methods determine proportions, and may ultimately develop æsthetic qualities, the scholarly and critical analysis and employment of traditional architectural forms, suitably modified for execution in concrete, is the proper method for the æsthetic treatment of concrete.

A historical review of the development of some characteristics of Egyptian, Greek and Roman architecture furnishes proofs of the non-relation of æsthetic treatment to direct constructive facts. Idealised representations of ancient types form the basis of both Egyptian and Greek characteristics, while the Romans frankly separated the decorative from the practical purposes of architecture. In Gothic art, however, the constructive craftsman was the artist, and the development of decoration is integral with building craft. In the other crafts of wood and plaster work motives are imitated from stonework and illustrate the modifications produced by the texture of the material into the design of details : of this the Elizabethan ornamental plastered ceilings originated from Tudor vaultings are illustrations.

Modern novelty of constructive method does not remove necessity for study of architectural development, but it will aid adaptation and modification, and thus pave the way for development. Modern Continental design is too eager to demonstrate elasticity possible in employment of form in unusual architectural relations. At home we still are safely and timidly putting brick and stone fronts to concrete buildings. There is a great future before concrete building, and it deserves that close and patient architectural study which deriving from the past will give certainly to the future æsthetic treatment of the material.

DISCUSSION.

Mr. H. Heathcote Statham, F.R.I.B.A., after proposing a vote of thanks to Professor Pite for his exceedingly interesting and well-thought-out paper, said he had been waiting rather anxiously throughout the paper to see to what conclusion the author meant to lead them, because at first it appeared they were to be rebuked for desiring to use old architectural forms, but the Professor's conclusion appeared to be that they should aim at a treatment of concrete suitable to its texture, and not ignore the ancient traditional forms. On the whole, Mr. Statham was disposed to agree with that, if it were possible. He agreed also with the great importance of tetxure in the material as a suggestion for treatment.

He was not sure whether Professor Pite intended to condemn the use of brick and stone facing. It seemed an easy and not very sincere way out of the difficulty, but after all it was the method employed by the greatest concrete builders of all time—the Romans—and there might be something to be said for it. He (Mr. Statham) would be more interested to see something like the treatment of concrete itself with its natural texture exposed, a treatment which the Professor indicated might be suggested by traditional forms, which would be altered in order to suit the material; but it would be a very difficult task, and one that could not be accomplished in a day or even in a few years.

As to the argument which ran through the paper, that the Egyptian and Greek styles had really arisen on the transformation of original ideas to a new material, Mr. Statham declared himself unable to believe that, and was rather sceptical about the mud origin of Egyptian architecture, and the wooden origin of Greek architecture. He did not believe, either, in the wooden origin of the Doric column, for the reason that the further back one went, the thicker the columns became. If it were traced back to wooden origin, the position would have been surely the reverse.

The final conclusion emerging from the paper appeared to be that they could perhaps originate an architectural treatment suitable to the texture of concrete, and without altogether forgetting architectural tradition.

Mr. A. Alban H. Scott, M.S.A., in seconding the vote of thanks, said he also had been listening for some sort of lead as to the correct treatment of concrete, but after all it was rather difficult to give definite opinion, because so much depended upon the building and its situation. London particularly was exceptionally difficult for the treatment of concrete. He had in mind some Colonial work, where the surface of the concrete was left exactly as it came from the centreing, with the exception of the small projections between the boards which were roughly taken off, and the whole surface distempered. That gave a most pleasing effect, but was perhaps hardly suitable for a place like London. He was unable to see how a building like the General Post Office, for instance, could have been treated otherwise than by applied material and another material.

The greatest trouble they were likely to have in the future as to the æsthetic treatment of concrete was with the so-called specialists. Engineers were rather getting on to buildings, and the great difficulty of getting proper treatment of reinforced concrete lay in the work gradually leaving the architect's hands, and getting into the hands of the purely constructional man. So long as this condition obtained they were unlikely to get anything satisfactory, except purely by accident. Of course, bridges and similar structures were much easier to treat, and it certainly seemed a shame to cover concrete in any way whatever where it was possible to avoid it. He was prepared to see concrete with its natural face exposed, rather than covered by plastering or rendering of any description. The material required no protection if properly executed, and it was wrong to plaster up the front, unless of course the intention was to go in for an elaborate colour scheme, when they would get atrocities very quickly. The tendency should be to go purely on lines of simplicity, omitting mouldings wherever possible, and relying on light and shade, upon projections and proportions of arches, and so forth, and getting rid of as much ornament as possible.

Mr. Edwin O. Sachs, F.R.S.(Ed.), thought the paper one which was of the highest standard, and which required careful perusal and thinking out at leisure.

As to Mr. Scott's fear that concrete would be in a bad way if left in the hands of the engineer, he differed from that entirely. The concrete engineering works that he had seen had generally struck him as some of the most beautiful works that the world possessed, if undecorated and without any attempt at architectural treatment such as obtained in the miserable Tower Bridge. Concrete works of that character expressed their purpose splendidly, and gave an excellent idea of how material had been used to the best advantage, and it was an actual pleasure to look at them. The Forth Bridge, for instance, as a perfect steel structure, was an expression of beauty, in the sense of being something which was useful and economic. The Assouan Dam was one of the most beautiful structures he had ever seen, simple as it was, for it showed the work it performed, and how economically it had been done.

In his view an artificial covering to a useful and well-proportioned structure was generally a drawback. Concrete architecture was likely to find its salvation in the hands of the civil engineer, especially if he remembered the use of surface treatment. There was really no difficulty in getting a good surface to concrete. In Austria one found innumerable examples of excellent surface treatment, but of course it required a little extra expense in the centerings and boarding generally. The expense, however, was by no means prohibitive.

Mr. J. Ernest Franck: It seemed that the conclusion at which Professor Pite arrived was almost a contradiction in terms. That conclusion appeared to be that they must take the whole of the work that had been done before ; they must have a knowledge of it before they attempted to design in a new material, and before they attempted to produce a treatment which would show the principles of the material in its constructive sense, and beauty in outline and proportion. Yet, if they started from the study of the work that had been done before, he was afraid from what had been shown on the screen that they would arrive at a treatment of material totally opposite from the standpoint from which they started. Therefore, it appeared that originality would be debarred in treatment, because many questions arose as to what could be called beauty of construction, and many principles were laid down as to what constituted true proportion in stonework and woodwork.

The Professor had said that beauty could not perhaps be altogether expected in designs for a hospital ward. The size of the windows and the proportions of the building were laid down, and must be adhered to. But with all those conditions, some men had produced fine buildings with beauty of outline, æsthetically good and sound ; and with all the limitations of reinforced concrete, perhaps somebody would rise to the occasion in future and produce a building which was even æsthetically sound.

Professor Pite had spoken of thin walls, but Mr. Franck believed that thin walls of reinforced concrete would be a mistake from a constructional point of view. A building should perhaps take the form more of stanchions and lintels with a filling, and that would mean quite a separate treatment, if they were going to show a building consisting of thin walling where it would be necessary to indicate, as it were, the homogeneity of the structure. Whether they should begin simply to apply stone façades to concrete construction, and show that it was simply a stone façade, or whether marble lining or tiling could be applied to such buildings, was really quite an open question. They had seen one illustration certainly on the screen of the Pantheon at Rome, with a marble interior, and he believed that the baths exhibited were also treated in a similar way with marble lining, but if a reinforced concrete building were treated in a similar way, it would not indicate altogether the difference in structure, and the æsthetic treatment of the marble would have to be on rather different lines from that which had gone before to show it. That was what he meant really when he said that the conclusions of the paper were rather a contradiction of the original principles laid down.

Mr. C. H. Colson, M.Inst.C.E., assumed that as an engineer he was not supposed to know much about beauty, but if in future he had to design buildings which were required to have a certain amount of beauty, his aim would be to carry out a vertical style of architecture—a building largely supported by verticals, and in which advantage was taken, as far as possible, of the character of the material being dealt with. The material would be massed more or less in uprights and in beams, rather than spread over large surfaces. He would avoid all scabs of cement on the surface, or treatment of that class. By using different aggregates, it was possible to obtain a large variety of different textures and colours, and they would be lasting.

One point in the discussion seemed to be that beauty was regarded as a thing which was never to change. Surely that was not correct. What was regarded as beauty in one age was not necessarily so interpreted in another, and he was unable to follow the principle that they should always strain after what had gone before. Rather should they allow the new material to bring its own ideas of beauty in the future.

Mr. A. E. Corbett, F.R.I.B.A.: The only criticism he could personally suggest of Professor Pite's paper was that perhaps the engineering aspect of the question had been too much omitted. It seemed that whenever the Professor was approaching anything like a broad treatment of things, he regarded it as pure engineering and consequently outside his subject. That, however, was just the very treatment which should be tackled and made most of, and it was perhaps not work which should be done either by an architect or an engineer. The proper man was an architect who had very sincerely studied engineering, or an engineer who had gone through a very thorough training in architecture, and the way to begin was with purely utilitarian structures.

He was a little surprised to hear from Professor Pite the suggestion of covering up concrete structures with stone. It was a safe doctrine, no doubt, but it was not the way to get on. Could not a beginning be made with such things as warehouses, where the client did not expect very much ? They might be able to treat warehouses almost from an engineering point of view, with also a little architectural treatment.

Professor Pite, it seemed, had rather scoffed at the Forth Bridge as a thing of Beauty, but if its equivalent in reinforced concrete could be obtained in a building, which expressed reinforced concrete as well as the Forth Bridge expressed steel construction, they would be a long way on the correct road.

Mr. Percival M. Fraser, A.R.I.B.A.: It was a pity that the paper was not the " Æsthetic Treatment of Reinforced Concrete " ; it would have been far more useful. There was as much difference between concrete and reinforced concrete as there was between brick and reinforced concrete. Concrete without reinforcement was entirely different. Its bulk was different, its design was different, its uses were quite different. Reinforced concrete had many peculiarities which had not been touched upon at all by Professor Beresford Pite. The architecture of past ages had been variously classified. He remembered a very pertinent classification, namely, the architecture of the *beam*, and later the architecture of the *arch*. Could they not find some outside classification for reinforced concrete, such as the architecture of the bracket ? The bracket was, in his opinion, one of the great peculiarities of reinforced concrete, because it could be extended and enlarged in such an extraordinary manner. Those who had seen M. Hennebique's house or the Auteuil Works at Paris, could not have failed to have been impressed by the wonderful uses the bracket had been put to and the influence it was likely to have on design.

He saw no reason for anything blasphemous in facing reinforced concrete with stone. He did not know that reinforced concrete or concrete was a nobler material than brick, and in London, of course, it was freely faced with stone. In the country, in those localities where stone was readily obtainable, the walls were generally solid, but reinforced concrete in towns was made up of materials which were brought from outside the town and imported materials, and it was quite feasible to face with stone. He was not a lover of stone facings for buildings, but he thought the obvious treatment of reinforced concrete was to block out the masses and to treat with plaster ornament, or better, perhaps, mosaic.

The Chairman (Sir Henry Tanner) put the motion of thanks to Professor Beresford Pite and it was carried by acclamation.

In presenting the vote of thanks, Sir Henry Tanner said it seemed to him that reinforced concrete had to be considered from different standpoints. If they had it in a building in a town, it had to be treated in a different manner from the country, or in an engineering structure. In an engineering structure there was no reason to cover it in any way ; it made a very good face itself. But in a town or city where they wanted something more architectural, they must adopt some other material. He did not think that concrete pure and unadorned would exactly suit a city, say the City of London. It would be exceedingly dirty in a very short time. He did not say that any other surface kept clean, but people would not be satisfied with it. They wanted a better appearance, they wanted to spend a little more money ; as a matter of fact they would not think it of sufficient importance. That led him to adopt stone for the street fronts of the Post Office.

So far as Professor Beresford Pite went, it seemed he rather supported the use, more or less, of ancient architecture as an adornment for concrete. A remark made by Mr. Corbett was very much to the point; in fact he agreed with him so far as street architecture was concerned, but when they came to warehouses, they could adopt some more visible use of the concrete. That was what he should do himself if he were to build a warehouse. The constructor had the opportunity of exhibiting the pillars and the lintels, so that they formed really a series of screens between the pillars on the different floor levels.

THE LECTURER'S REPLY.

Professor Beresford Pite suggested that when the paper was printed and digested by members of the Institute, they must have an extended discussion, because he thought the subject was one of very great importance. If the Institute would find the opportunity, possibly the study of the paper must be useful, because he was sorry to say that he found it practically impossible to write these papers in advance. These subjects grew in one's mind so steadily and so persistently that until they came to the climax of having actually to be produced one really did not find one's self in the position to feel much enthusiasm about them.

A great many very interesting points had evolved themselves in the course of the discussion, but he could only prepare the way for a future discussion by saying he disputed the right of engineers to æsthetically deal with the subject without training. They had no more right to sit down and talk about how they were to design masses, design vertical and horizontal forms, than he had, as an architect, to discuss with them how he was to design an enormous concrete work. If he knew, he should expect them to listen to him ; if they knew, he should listen to them with pleasure, but they did not ; they absolutely did not. There was no evidence in their works that they did.

The subject they had was "The Æsthetic Treatment of Concrete," not the subject of what the engineers would do, and he devoted the preface to the paper to that. What the engineer had to do was to be done soundly, honestly and naturally, and thus unconsciously be æsthetic. It was when the engineer attempted to be consciously æsthetic that he exposed the cloven hoof. As long as he would be as unconscious as Sir Benjamin Baker was when he produced the Forth Bridge, which he did not scoff at, he would be truly æsthetic. Why did not the Council of the Institute invite a distinguished engineer to read a paper on the "Æsthetic Treatment of Concrete Buildings?" They should have listened with delight and pleasure. He should have been vastly interested to find the line that a professional engineer would have pursued.

His point was that they could not separate a concrete building from the laws which governed other buildings. They must have the natural and inevitable results of utilitarian and constructive law accumulating in æsthetic force and value. They had them in the Forth Bridge, in a gasometer, and a number of other ways ; they had it in the original basis of other styles of architecture, but ultimately the language that they spoke, the music that they heard, the architecture that they saw, were the results of a long process, a world-wide historic process of the evolution of form. The creation of doctrine on this evolution needed understanding. It was not very remote, but it was very wide ; it was not very difficult, but it required time and training, and, on this subject, architecture spoke with authority. This was the æsthetic aspect of a practical subject on which he had the honour to be invited to address them, and if at any other time the Concrete Institute invited a practical engineer to deal with this subject, he had no doubt they should have as interesting a discussion as if the Institute of British Architects invited one of their ordinary members to deal with a highly complex engineering topic and invited the engineers to criticise it.

With regard to the façade treatment of stone and brick work, Mr. Corbett suggested he was unexpectedly cowardly about that. That was only because he had forgotten his words. He was not at all. It must have been cowardly if he had not referred to the subject. With Sir Henry Tanner in the chair, he thought it would be more courageous to do so, and so he simply remarked that, until they had progressed in the adaptation of architectural form to their new material, till their architectural forms had acquired the texture of concrete, the path of least resistance, of safety, and of modesty, had been and still was to mask the concrete quality by a surface treatment. The whole object of his paper was to direct the line upon which, after study, the realisation of the texture could proceed. His own personal and private opinion was that he should very much prefer Sir Henry Tanner's architecture, just as he designed it, but executed in concrete without joints. It would lead them a step further on the evolution of this textural adaptation of architectural forms to the new material. Sir Henry Tanner's action in the matter was characteristic, was just as true to the age in which they lived as the casing of any steel structure with brick or any other material. To case it with a noble material, because it was an ignoble material on a noble site, was, of course, a perfectly logical and defensible position. No one expected Sir Henry Tanner to embark on æsthetic experiments with a new material in the heart of the City of London.

He would like to suggest to them that, with all the honest directness of practical construction, there were occasions when they wanted to decorate. There were occasions when they wanted to manifest pleasure permanently ; he did not mean for the purpose of Coronation decorations, but permanently. There was no reason why a great bridge should not be thrown across the Thames, one whacking great cantelever right over St. Paul's Churchyard to Bethlem, one real great thing as big as the Forth Bridge going right over, to take the world right over the river, over the slums, and land them somewhere in the neighbourhood of the Elephant and Castle. There was no reason why one great bridge, on the principle of the cantelever, the central span of the Forth Bridge, should not be undertaken. But Sir Benjamin Baker would not have undertaken to decorate it, and the engineers were not qualified to undertake it. As a civic monument, the architectural necessities would demand it. It would demand a powerful and attractive system of ornament and decoration.

As to the ultimate standards of beauty, he reminded them that there were such things. Of course, ideas of beauty changed very rapidly. It must have ethnic limitations that was to say ; what was ultimately beautiful to the Japanese and the Chinese and the Hindu was not ultimately beautiful to themselves as Europeans, but he was persuaded there were subtle and fundamental elements of beauty in the greater monumental arts which were common to mankind and of common perception. The fact that they enjoyed, derived pleasure from the forms which delighted Pericles and Demosthenes and the great Greeks was a fact to grip. It meant that there was something in the world which lasted. It was their business to find out the secret of this æsthetic element. The engineer was one who was concerned with the flying buttress, stress and strain, but the other fact was there, a fact which had to be dealt with, a fact which was a proper object of inquiry.

One other suggestion was made by Mr. Malcolm Fraser as to simple classifications as applied to reinforced concrete. There was nothing in his paper which would not be as applicable to reinforced concrete, as to concrete that was not reinforced, or in any other form. The principles underlying were just the same. If he were to take mediæval architecture and discuss with them entirely architecture in stone, he should be discussing very much architecture in brick or architecture in concrete which was not reinforced, but if he turned to discuss with them mediæval half-timber framing with the bracketting and the pinning of the joints supplying the points of strength where the stress existed, he should be treading very, very nearly on the parallel path of the designer of modern reinforced-concrete.

The Chairman promised they should do their best to carry out Professor Beresford Pite's suggestion that they should have a further meeting on the subject. He was sure it would be of extreme interest to everybody, and, if they could get an engineer, they would do so.

THE Y.M.C.A. BUILDING, MANCHESTER.

By ALFRED E. CORBETT, F.R.I.B.A. (of Woodhouse, Corbett & Dean).

This very useful paper, which was accompanied by some excellent illustrations, claims careful attention. This structure was dealt with by us in our issue of May, 1911, and for the purposes of illustration we repeat two views of the building which have already been published in our paper, and we would also refer our readers to the drawings which illustrated the article in question.

Below will be found an extract of the paper and the subsequent discussion:—

INTRODUCTION.

Special Reasons for Adoption of Reinforced Concrete.—The original working drawings were made with a view to brick walls and skeleton steel construction; and the decision, when they were nearly completed, to make it a reinforced concrete structure was largely due to two parts of the building which seemed peculiarly suited for such construction.

The swimming bath, 60 ft. by 21 ft., on the top floor of the building, might have been constructed as an iron tank, lined with asphalt and glazed brickwork, but the initial cost and maintenance would be considerable. Reinforced concrete seemed much the simplest method to adopt for this tank.

The other special construction was the method of spanning the large hall, a 50-ft. span, without columns. The floor above the hall consists of class-rooms, and was so arranged that the division walls between the class-rooms should form trussed girders 12 ft. deep and 50-ft. span, supporting the floors of the class-rooms, and of the gymnasium immediately over them. These trusses were designed in steel, with the intention of enclosing them in solid concrete walls for preservation, but it seemed more reasonable to use the concrete for constructional as well as protective purposes by reinforcing it with about one-sixth of the amount of steel required in a steel truss.

These special considerations, allied to the ordinary advantages, induced us to carry out the work in reinforced concrete; and now that the work is finished we are convinced that the right decision was come to, in spite of the difficulties which we had to surmount.

Approval by Local Authority.—The first and most serious difficulty was with the Corporation. At that time the material was not recognised in the Manchester by-laws, and although powers to deal with it were being applied for, we were too early to get a ready consent to our proposals. Eventually we received approval of the plans, subject to no external wall being less than 9 in. thick. Partly to this delay, and partly to the elevations having been designed for brick walls in the first instance, is due the thickness of the walls in some places.

Specification Clauses.—We invited schemes from five firms of specialists, accompanied by tenders from contractors nominated by the specialists.

Each firm of specialists was supplied with a set of one-eighth scale working drawings, the eight sections having been altered to show reinforced-concrete construction, and the eleven plans still showing brick walls.

A specification was also supplied, and some clauses may perhaps be discussed with advantage.

View of Finished Building.
Y.M.C.A. Building, Manchester.

The floor load throughout the building was to be 2 cwts. per sq. ft., in addition to weight of floor. This high load was adopted at the request of the city authorities, we ourselves having intended to allow 1½ cwts. per sq. ft., which would have been quite ample.

Provision was made for testing steel and cement before use; and for tests of portions of the flooring two months old with a super load of 3 cwt. per sq. ft., the deflection not to exceed $\frac{1}{360}$ of the span.

The following rather drastic clauses were also introduced :

> " If the results of compression tests of sample cubes of concrete show the strength of concrete to be less than 95 per cent. of the strength allowed for in the calculations the architects may require all work done from the batch in question to be replaced by fresh concrete at the contractor's expense."
>
> " The architects may select any member or portion of the structure to be tested to destruction 28 days after moulding. The test piece may be either the actual part erected as a permanent part of the building, or an exactly similar piece made for the test, or a model on a reduced scale. If the pieces tested should fail under a load of less than four times the calculated safe load, the corresponding part of the actual building shall be strengthened to the architect's satisfaction, and the whole cost of such strengthening, and of the test, shall be borne by the contractor. If the piece bear a load of four times the calculated safe load before breaking, the net cost of the piece and the cost of the test shall be borne by the proprietors."
>
> " The architects may order any additional tests on the understanding that if the result be according to the specification the proprietors shall bear the cost ; and if the result be not according to the specification the contractor shall bear the cost."

These powers were not made use of, but something of the kind would be of value should there be reason to suspect bad work, or should there be any difference of opinion as to the sufficiency of strength in the design of any member.

We also specified that provision should be made for skilled supervision during erection, and consequently had one of the specialist's engineers resident on the work, a very valuable factor of safety on such a complex work.

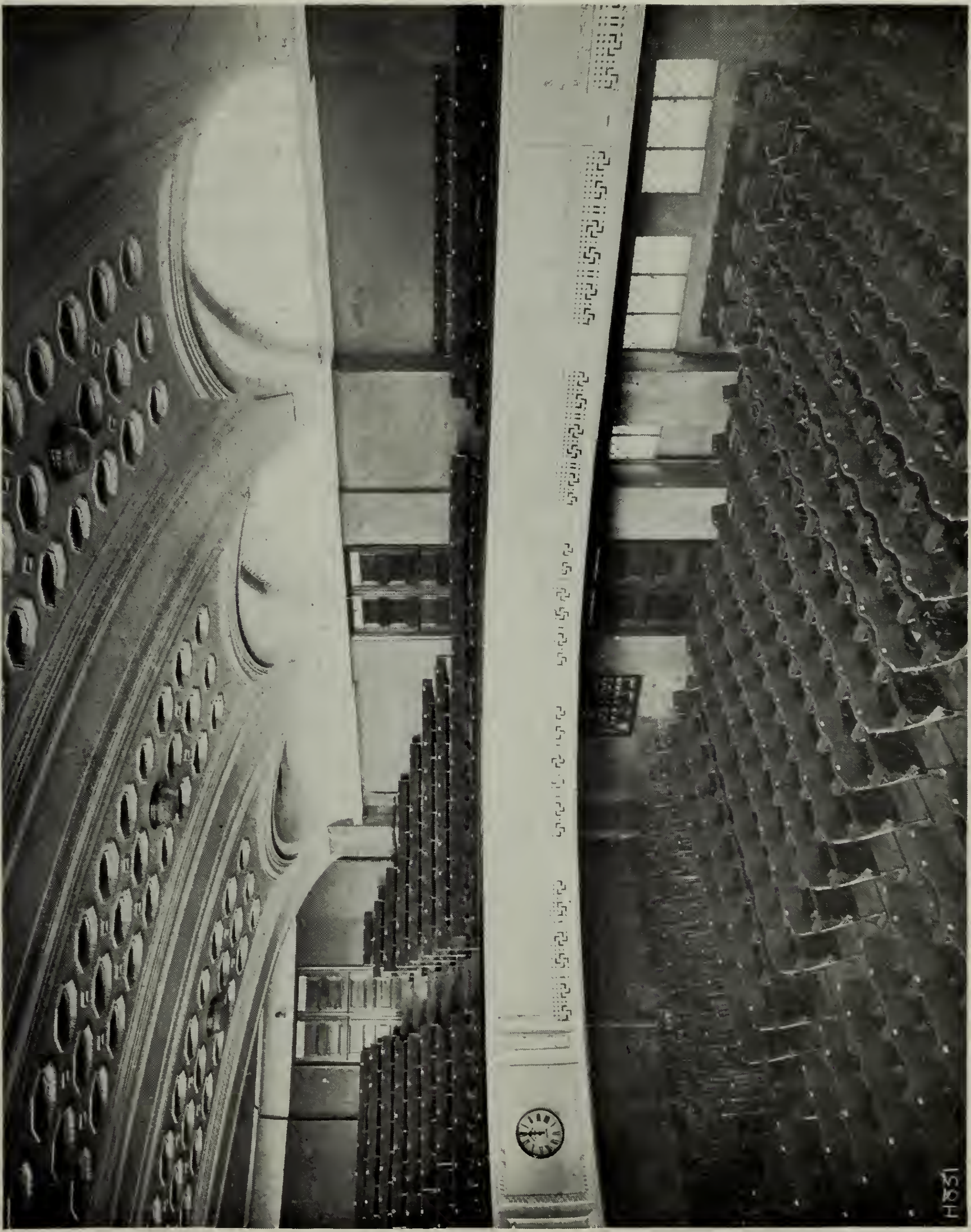
Comparison of Schemes.—We had asked the competing specialist firms to supply us with sufficient particulars to enable us to check the strengths of their respective schemes, and four out of the five complied with our request. It was, of course, impossible to check the entire design, but we selected typical members throughout the building and calculated their strength in accordance with the Report of the Joint Committee on Reinforced Concrete appointed by the Royal Institute of British Architects, and tabulated these as a percentage of the strength required.

After discussion with the firms concerned, it was decided to accept the tender of Messrs. J. Bentley & Co., of Bradford, for the scheme submitted by the Trussed Concrete Steel Co., Ltd., on the " Kahn " system. In addition to being next to the lowest in price, this scheme had various advantages, one being the increased resistance to sound transmission gained by hollow-tile floor construction. An important concession was made during the negotiations—viz., that in developing the working drawings every member should be calculated to the R.I.B.A. standard, the drawings and calculations being referred to Mr. C. F. Marsh, M.Inst.C.E., for him to decide if this was the case ; his fee to be paid by the specialists. This was of great value to us in getting the approval of the Corporation.

Tests of Cement and Concrete.—In defining the concrete to be used, instead of specifying materials and proportions, it formed part of the contract that the concrete at 28 days old should have a crushing strength of 154 tons per sq. ft., this being the standard given in the R.I.B.A. Report

A very interesting series of tests was then undertaken to ascertain the most suitable local materials and their proportions. The mixture adopted was 1 cwt. of cement, 3 cu. ft. of sand, and 6 cu. ft. of stone, the stone passing a $\frac{3}{4}$-in. mesh. This gave the required strength in the preliminary tests.

Our preliminary tests with various sands and stones showed the kind of sand used to be more important than the kind of stone. Other tests with the selected materials in eleven different proportions strongly supported the well-known fact that it is the proportion of cement to sand which governs the strength of concrete, rather than the proportion of cement to total aggregate.



Interior of Large Hall.
Y.M.C.A. Building, Manchester.

Another test showed the relative strength of concrete when used fresh, and when left standing for two, four, or six hours before moulding ; the latter cubes having respectively 84 per cent., 75 per cent., and 68 per cent. of the strength of fresh concrete.

Retaining Walls.—To pass on to actual construction, the whole of the foundations were on fairly hard red sandstone, on which a pressure of 7 tons per sq. ft. was allowed. The retaining walls were designed as beams subjected to a horizontal load, and supported at each end by a stanchion, instead of either depending on a sole piece for stability or acting as a vertical beam against the floor.

We had intended to trust to our concrete wall for resisting damp, but the Corporation insisted on a cavity wall, which we formed by means of a 3 in. brick-on-edge wall in cement inside the retaining wall.

Although the retaining walls were only from 6 in. to 14 in. thick, according to span and depth, we could not detect any leakage of moisture through them before the brick inner skins were built, except for a slight flaw in the joint with floor slab, and apparently they would have been quite satisfactory without a cavity.

Girders over Hall.—I have already referred to the large girders, 50-ft. span and 12 ft. deep, carrying the two floors over the large hall. These girders are very rigidly braced in position by being monolithic with the floors at top and bottom, the T head of the girder being a part of the upper, or gymnasium, floor. The only difficulty in designing them lay in the opening, 7 ft. 6 in. high by 6 ft. wide, required through the middle for a corridor, which reduced the resistance to any shearing stresses set up by unequal loading. This was overcome by a triangular frame of reinforcement round the opening. The girders, with their T heads, weigh about 47 tons each, which includes $2\frac{1}{4}$ tons of steel reinforcement, and are calculated to carry safely a load o 230 tons each, including weight of structure.

Roof Principals.—Over the gymnasium are a running-track gallery and two fives courts, presenting the same problem of a 50-ft. span without intermediate supports. In this case the four side walls of the fives courts were made into trussed girders or principals of about the shape of a queen-post roof truss. The only difficulty with these large principals was to get enough shearing resistance close to the supports, and the thickness was considerably increased at these points. The space between the centre pair is 30 ft. wide, making a central area 29 ft. high with a glazed roof supported by two curved secondary principals resting on purlins 3 ft. 6 in. deep.

Running Track.—From the fives-courts walls, or roof principals, hangers descend to support the running-track gallery. This was preferred to cantilevering, partly on account of want of head-room, and partly to avoid bending stress on the stanchions at their thinnest part.

The track parapet was made into a continuous beam 3 ft. high, and this spans 30 ft. between hangers at each side of the central lofty space.

The running-track surface was banked up from the concrete slab with curved wooden framing covered with boarding and cork carpet.

Swimming Bath.—Perhaps the most interesting part of the building is the fifth floor swimming bath, in which over 180 tons of water have a surface 57 ft. above the street.

It is simply a rectangular box, 60 ft. by 21 ft., with a water depth of from 3 ft. 6 in. to 6 ft. 6 in., and rests on transverse beams varying in depth from 3 ft. to 6 ft. 6 in, and 26-ft. span ; the thickness of bottom being $7\frac{1}{2}$ in. and the sides being from 5 in. to $6\frac{1}{2}$ in. thick.

We carefully considered whether to line it with asphalt or similar lining, and decided to trust to the concrete alone, simply lined with glazed tiles set in cement.

The concrete was specially graded with 1 volume of cement, $1\frac{1}{3}$ of sand, and

$2\frac{2}{3}$ of stone riddled through a $\frac{1}{2}$-in. mesh. The whole of the bottom slab was cast in one day. Five days afterwards the edges were grouted with neat cement, and the whole enclosing wall, up to water level, was cast in a single day.

As a precaution against leakage, a light tray 3 in. to 4 in. thick was constructed level with the soffit of the supporting beams, and this tray was asphalted.

Test of Bath.—Three months after casting, but before fixing the tile lining, the bath was very slowly filled with water, and readings were taken of the deflection of the two shallowest beams, which happened to be subject to the greatest weight of water. The maximum deflection, with the full 6 ft. 6 in. depth of water, was barely $\frac{1}{20}$ in., or under $\frac{1}{6000}$ of the span. It is interesting to note that the deflection of these beams corresponded closely to that of the gallery cantilever. There was no sign of the slightest crack in the bath itself, but it was rather surprising to note that exactly in the centre of the span this very slight deflection caused a crack in the soffit of the thin asphalted tray. This occurred in every bay, stopping about a foot short of the beam, and was obviously due to the reinforcement only being provided in one direction.

On first filling the bath there was a very slight leakage, as expected, but it did not exceed about a quart a day. Without any special treatment this very slight porosity of the concrete rapidly closed up, and in six or eight weeks the whole exterior of the bath was bone dry.

Four months after filling the bath was emptied and lined with white glazed tiles, and after an interval of three months was again filled, and was found to be perfectly dry externally.

Roof Beams.—In constructing the flat portions of the roof height underneath was very limited, and to prevent any loss of height all roof beams were put above the roof slab instead of below, with their ends chamfered off so as not to project above the coping. Holes were left through them for rain water to pass through, and by this means a level ceiling was secured at the greatest possible height. The flat roof was asphalted.

Posts for Handrail.—Near the edge of the roof a light handrail is supported by reinforced concrete posts, the posts being made strong enough to support a cradle for washing the walls.

Flagstaff.—The flagstaff, 27 ft. high, is of reinforced concrete, and is 10 in. diameter at the base and 6 in. at the top, cast solid of the same grade of concrete as the swimming bath, and reinforced by six $\frac{1}{2}$-in. bars. It was severely tested four months after casting, when a very large triangular flag, 14 ft. high by 26 ft. long, was run up on a very gusty day, and its tail so fastened, to display some lettering, that the flag happened to be at right angles to the wind. I had a very surprising demonstration of the elasticity of reinforced concrete, as the flagstaff whipped about like a piece of lance-wood. I could not take actual readings, but I estimated that it moved at least 4 in. out of the perpendicular in each direction, which would be a deflection of one-eightieth of its length. No sign of cracking was visible.

Fixing Steel Window Frames.—The steel window frames were specified to be built in as the work progressed. Practice on this point seems to vary, and later on we decided to insert the steel frames after the building was nearly completed, on account of risk of damage by buckling and by accident. A minor reason is the action of wet cement in destroying paint, and the consequent difficulty of keeping built-in frames free from rust. A V-groove was left or cut in the concrete, and the frames grouted up to it, being screwed to lugs let into the concrete.

Holes for Pipes.—The various holes required for steam and water-pipes, electric tubing, etc., were nearly all cut out afterwards, because of the difficulty of getting them in the exact positions if they were formed while casting the concrete. The disadvantage of cutting them afterwards is the risk of spalling off large lumps of concrete, and, even more serious, of cutting through the reinforcement.

So far as holes for stair balusters are concerned it is probably better to cast them, as they are too near the edge for safe cutting afterwards.

Many pipe holes were avoided by the provision of two chases from roof to sub-basement, large enough for a number of pipes and for access to same.

Tiling and Terrazzo.—The walls in some of the principal rooms and stairs are tiled with " Vitreous Tiles," and in the lavatories and kitchen, and round the swimming bath, are covered with marble terrazzo mosaic, which is a very suitable material for finishing a concrete structure internally, as it is really polished concrete with a marble aggregate, and does not introduce an alien material for finishing. Terrazzo was also used in the convenient form of reinforced slabs, 1½ in. thick, for w.c. or shower-bath divisions.

Area Whitewashed.—The internal light area was intended to be tiled, but considerations of price, of possible crazing of tiles, and possible detachment of tiles, led us to substitute cement rendering, which is to be periodically whitewashed. We think this was a right decision, seeing that no clear glass windows give a view of the area, as there is no doubt that the whitewash is a very effective reflector so long as it is reasonably clean, and it is very cheap to renew.

Acoustics.—Mention may be made of the acoustical qualities of the large hall, seating 900 people. Before building we had it from apparently good authorities that, firstly, such a hall built of reinforced concrete would reverberate like a huge drum ; and, secondly, that it would be so " dead " as to be so very bad for sound. Of these extreme prophecies the latter was much nearer the truth, and we added as much resonant material as possible in the shape of hollow fibrous plaster ceilings and gallery fronts, and thin fibrous plaster slabs firred out from the walls of gallery and back of platform.

The acoustical results proved to be very satisfactory. It is perhaps impossible to get absolute perfection for both speaking and music, and in this case the hall is exceptionally good for speaking, and slightly less good for music.

Hollow-Tile Floors.—The bulk of the floors throughout are constructed with hollow tiles separating 4-in. reinforced-concrete joists, to prevent transmission of sound. There is a remarkable difference between the reverberation of sound under the thin slab floors and the comparative deadness under the hollow-tile floors.

Temperature Cracks.—The floors were reinforced in one direction only, and this led to the occurrence of a few temperature cracks, the chief ones being in some of the slabs over the large hall. These occurred under the rather trying conditions of having the large hall fully warmed and in use, while the rooms over it were unglazed and exposed to cold weather ; the result being a few unimportant cracks parallel to the reinforcement. A small amount of transverse reinforcement would be well worth having, to avoid such cracks, although of course they do not affect the direct bearing power of the floor in the direction of its span, but only the transverse strength.

Floor Surface.—The surface finish of the floors generally is " Ebnerite," one of the patent jointless floorings which needs no floating, but itself fills up any slight irregularities in the concrete. This is also used on the staircases.

Dryness of Building.—It would be interesting to hear other opinions as to the relative dryness of brick and of reinforced-concrete buildings at the time when one wishes to introduce joinery. In our opinion reinforced concrete is very much drier than brick, and will generally give no occasion for artificial drying.

Safety of Construction.—Another useful point is the increased safety of construction, due to floors and staircases being completed as the building goes up.

COST PER CUBIC FOOT.

I cannot give you the cost as finally adjusted, but we believe this will be very close to the original amount stipulated, viz., £35,000.

The cost per cubic foot, measured from under-side of concrete foundations to top of roof, works out about as follows :—

	Per ft. cube
Complete reinforced concrete structure, including walls and floors and filling to terra-cotta, excluding excavating	3·0d.
Terra-cotta facing, including fixing	1·1d.
All other trades together	5·1d.
Total approximate cost	9·2d.

Time of Building.—The first slab of concrete was laid on April 29th, 1909, and the concrete structure was completed on September 15th, 1910, so that the complete concrete and terra-cotta shell occupied 16½ months in erection, which was considerably more than we expected.

DISCUSSION.

The Chairman (Mr. E. P. Wells) heartily thanked Mr. Corbett for his Paper, and said he would have much pleasure in moving a vote of thanks to the author, after the discussion.

Mr. W. G. Perkins (District Surveyor, Holborn) : He only had the paper put into his hand before entering the room and consequently had had no time to study it properly. The first thing that struck him was that it seemed rather unreasonable on the part of the Manchester authorities to require such a high super-load to be adopted in making the calculations for the floors. As District Surveyor of Holborn he had under his supervision the London Y.M.C.A. building at present in course of construction, and there he had agreed with the architect, Mr. Rowland Plumbe, to adopt loads varying from 70 to 120 lbs. per sq. ft. in addition to the weight of the floor, according to the position of the floor in the building. He did not know whether the Manchester authorities worked under a special Act, or whether they had by-laws, but it seemed desirable that they should have some Act which should specify the load, much in the same way as super-loads were specified in the London County Council General Powers Act, 1909, where loads were laid down for floors in various types of building.

He was glad Mr. Corbett had called attention to the usual method of testing floors. It was a fact that about half a bay on each side of a beam or cantilever was tested, and the parties making the test pointed with pride to the very small deflection that occurred. If they loaded the whole of the bay, as indicated by Mr. Corbett's drawing, some different results would have been attained. In the London Y.M.C.A. building just the same problem had to be faced with regard to the large girders over the hall. Instead of one corridor opening, they had three, and the beams had been trussed in the form of N girders, much the same construction as Mr. Corbett had adopted.

With regard to the holes for pipes, he found that in reinforced concrete buildings these holes and chases for pipes and electric wires were a great nuisance. Recently in a large public building, he found a firm of hot-water engineers merrily cutting chases at points of maximum stress, which chases varied in depth from 1½ to 4-in. in a 6-in. floor. He had these pipes taken out and the whole wetted and grouted and filled in with fresh concrete. At the Y.M.C.A. building, London, these chases were cut out by a pneumatic machine, and then the chases were blown out by compressed air prior to the pipes being laid and grouted in, which appeared to him a very economical way of doing it.

If they found any difficulty in getting plaster to adhere to concrete, which generally came out with a very smooth face, the best way was to lightly sprinkle the centreing with a little coke breeze, and by this means a very good surface for plaster was obtainable.

He quite agreed with the author as to what he said about whitening. Glazed tiles invariably became cracked, and the glaze got dull and dirty, and in five or six years ceased to reflect any light at all. If the walls were rendered and cemented and periodically whitewashed, a much better result was obtained.

It was advisable in all cases to have some amount of transverse reinforcement in slabs, not only to prevent temperature stress, but in order to distribute loads over the reinforcements, which were let in to take the stress.

Mr. G. C. Workman had very much pleasure in thanking Mr. Corbett for his excellent paper, which was especially extremely interesting to him, because he had to deal with the building in preparing a preliminary scheme, and he knew the tremendous difficulties with which the architects had had to deal. He inquired why the swimming bath was put on the fourth floor, for there must have been some reason ? Would it not have been preferable to have put it in the basement ?

Regarding the by-laws, he thought great praise was due to Messrs. Woodhouse, Corbett and Dean for boldly designing such a huge building in a comparatively new material, well knowing that there were no actual by-laws at the time, and that consequently there would be considerable delay and difficulty in getting the building passed. The sooner all districts got proper by-laws, the better.

The very heavy super-load of 2 cwt. per sq. ft., upon which the building had been calculated, was absurd. It was far more than was required, and he should like to know whether the actual by-laws were still going to require these 2 cwts. for small buildings in Manchester, because, as far as he could remember, it was $1\frac{1}{2}$ cwts. ?

He noticed that $\frac{1}{360}$ of a span was specified in connection with the measure of deflection and that Mr. Corbett recognised that $\frac{1}{600}$ would have been quite good enough. He was very pleased to hear that, because one was met sometimes with a stipulation that $\frac{1}{360}$ of a span must be the maximum deflection under load. Mr. Corbett had not told them, but he supposed the test load consisted of 50 per cent. in excess of the super-load ?

Mr. Corbett.—That was specified, but we did not do it. We did do the actual super-load of 2 cwt.

Mr. Workman.—In what consisted the test then ?

Mr. Corbett.—We thought that 2 cwt. was such an absurdly high load, that it was good enough for a test.

Mr. Workman.—That is simply applying the super-load ?

Mr. Corbett.—Yes.

Mr. Workman thought they did not expect any deflection. If they applied the super-load on a floor, they did not expect any deflection whatever. If they applied 50 per cent. more, of course they did expect a deflection, but they did not expect that deflection to be permanent unless they were pretty heavy beams, considerable span, and not very much height. With a very heavy dead-load, they might have a little permanent deflection ; it depended very much on the circumstances, but if they simply applied the load for which the floor had been calculated—the normal load—then it was not a test.

Adverting to the $\frac{1}{360}$ of the span, he had recently had to face the following specification for a test : The floor was to be loaded to 100 per cent. of the super-load—namely, twice the super-load—the deflection was not to exceed $\frac{1}{360}$ of the span, and there was to be no permanent deflection.

It seemed to him that those conditions very clearly showed that some definite regulation ought to be made as to what was really the deflection that was going to be chosen and selected. They had taken $\frac{1}{600}$ of a span because they found, when coming to this country, that Messrs. Hennebique had already that stipulation, and while there was absolutely no reason for it, if it was good enough for that firm it was good enough for them. The proper deflection of a beam ought to be calculated in each case, but it was a matter which varied. It varied with a lot of circumstances and when one said they would put a super-imposed load of 50 per cent. in excess of the super-load, and the maximum deflection was not to be greater than $\frac{1}{600}$ of the span, it simply meant that to all intents and purposes it was quite satisfactory. It was never attained in practice, but it was, as a matter of fact, very elastic. The accurate thing would be that the engineer supplying the design should say: "You are going to test this beam. Now, this is the deflection which we have calculated, and which you must reach under such and such a test load."

Mr. Corbett had mentioned that the firm insisted upon having emergency props in case the test was not satisfactory and the structure came down. He was glad to hear that they thought it advisable to stipulate that. He knew very well it was an excellent precaution if by any chance the work had been badly done, or the tensional bars were placed in the top portion of the beam, which sometimes did happen accidentally, and there was nothing to take the tension in the bottom of the beam, and the floor did crack and threaten to come down. There was time to look into things because the emergency props were there, and you knew you were not going to have a serious collapse. He was very glad to hear that Messrs. Woodhouse, Corbett and Dean had thought it advisable, and he did not think tests ought to be carried out without this very necessary precautionary measure.

He noticed that they had had cracks in the floors. There was hardly one of these reinforced concrete buildings that had not got cracks. The proprietors of some systems would tell you, "Oh, our system never has any cracks." It might be so, but there was one thing quite sure, they could not have a rich mixture of concrete such as they all had with these reinforced concrete buildings without having expansion cracks. It was simply the law of Nature. It did not matter how much steel was put in, they would have cracks somewhere or other, and they were nearly always at the weakest point of the structure. It was necessary, as far as possible, to reinforce the concrete in such a manner as to diminish these cracks, to try to obviate them as much as possible, because if they did not do that they would have very large cracks in certain parts, and it might be rather annoying in the plaster of a ceiling, for instance, where they might be unsightly, but not dangerous, because, as Mr. Corbett had pointed out, the cracks were parallel to the main reinforcement, and although you could put a knife in one of those cracks, it would not in any way affect the strength of the floor. They quite recognised that, but they were not sightly things, and it was for that reason that he had heard a gentlemen there point out that sectional bars or distributing rods should always be provided. Mr. Corbett and Mr. Perkins drew attention to the fact that it was not a commendable practice to simply reinforce a slab in one direction without putting distributing rods.

That brought him to another subject. In competing for a scheme like this, the great point was to have a low price. He knew very well that when they went into it, they put in distributing rods, but the system which had been adopted did not put in any. Experience had proved that distributing rods were necessary, and he was pleased to see that that had been borne out in practice. It had been pointed out to him very often that it was quite a waste of steel to put the distributing rods in, and he was almost on the point in one case of taking upon himself to knock all the distributing rods out, and simply put in the main reinforcement in the slab. He was then told by the firm's engineer: "Well, you will have far more cracks than you would have otherwise. You might otherwise have small cracks due to contraction, but if you do not put in the distributing rods you will have far more." Then he had said: "Well, what am I to do? My design must be cheaper. If it is not cheaper, we will be out of it." They had decided to put the distributing rods in, and if they missed the job they would miss it. They did miss it, but it could not be helped.

It all came to this, that the way specialists had to put their schemes before architects at the present time was very unsatisfactory, because it was simply a premium on bad design, and to a certain extent on bad workmanship, and he would very strongly urge that architects should first make a selection as much as possible between the various systems which were in the market now; choose the one they thought best, and adopt that one, but not of necessity that all these systems should be put in competition and the lowest tender accepted, because it led to this kind of thing, that eventually in the course of construction of the work it was found out that perhaps if this or that had been taken into account it might have been better; and, of course, the conscientious methods took into account all those difficulties at the start, with the obvious result that they were thrown out of competition, not being the cheapest.

He was bound to dwell a little on this last portion, because it was beginning to be a very serious thing for the various firms of reinforced concrete engineers. They got flooded with demands from all parts of the country with schemes from architects. They did not like to offend them, but at the same time they had to draw their attention to the fact that they should like them to make up their minds and to select a system beforehand. He quite realised what the difficulties were, and he would welcome the day when the architects could see their way to gaining all the necessary knowledge and spend it on the selection of the method of construction which they were going ultimately to adopt.

Mr. M. E. Yeatman.—Regarding the provision of safety props under a test load, he thought that was most desirable, and it was no slight on the excellence of the construction in any way. If a test was to be applied, it surely implied that there was some possibility of its proving a failure, or there would be no necessity to apply it, and if it was possible that the floor might not stand the dead-load of 2 cwt. per sq. ft., or 20 tons or whatever it might be in all, it was pretty certain the floor below would not stand the load of 20 tons falling 10 ft. on to it, especially if it was an upper floor; there might be three or four floors underneath. They would all go one after the other.

He quite sympathised with the difficulties of the competitive tenderers, when they did not know whether to scamp their design a little or be conscientious and not get the job. It often came to that, but he did think the people who asked for competitive designs should employ a competent and careful engineer to examine between them, and to report not what was the cheapest job altogether, but what gave best value for their money. If they did that, then those who tendered fairly and conscientiously would have a chance of reaping the advantage. There was a great temptation to do otherwise, because there was always a chance that something might slip through and the design might be accepted because it was the cheapest, though not the best.

Regarding this particular design, there were many most interesting features in it, including the deep cross girders and the swimming bath on the upper floor. He should like to hear from Mr. Corbett if he knew the reason for putting the bath so high? Was it to give a reserve of water for fire prevention? That might be the reason for putting it on the upper floor.

Mr. S. Bylander thought it was a very pleasing thing indeed that the author had let them see the working drawings and had also given very complete details of his difficulties. That was what they wanted to know; they did not want to know so much of the theoretical part as of the practical difficulties. He much valued the paper presented, because he had previously seen the drawings and estimated on them.

He thought the fact that an expert was employed during the execution of the work was the most excellent point that he had seen applied. The same problem was suggested at the time of sending in specifications, and he should be very glad to know if Mr. Corbett could tell them what arrangements he made, or what arrangements he now suggested should be made in a similar case, as to how this expert should be paid? He thought he should be the servant of the architect, be quite independent, and be paid by the client. He considered the value of such an expert was of much more importance than the selection of the particular system. The main thing was that the work was properly designed in accordance with the loads and good engineering practice, and that the work was carried out correctly. Most of the failures that had taken place had been due to careless work, and not so much on account of ignorance on the part of the engineer or draughtsman.

Mr. Corbett had said that the authorities required that the floors should carry a super-load of 2 cwt. It was very well that certain specifications should be given, but to what extent had the authorities checked the work as executed? He thought it was more important that the authorities should have a qualified man who understood the work to check the actual carrying out of the work than to impose very severe conditions.

He noticed what Mr. Corbett mentioned about test loads for floor panels, and he undoubtedly thought the particular case referred to was one which was very suitable for a test. He did not very much believe in testing a floor slab of simple construction, as that could easily be figured, provided the calculations were right and the work was carried out correctly. He hardly thought it necessary to have a test made. His idea was that a floor slab and a beam were so easily calculated, that the danger of any failure was so small compared with that which may take place in a column, or a connection between a main girder and a column, that the really difficult part of the structure which should be tested should really be the column; and he should like to know whether any arrangement was made, or any test made at all, of the column?

He understood the columns were designed so that the pier was really a rectangular concrete pier reinforced in the centre. Therefore you had to deal with part of the concrete outside and part inside. He took it the concrete inside was calculated to carry the load, and the concrete outside was simply there to fill the space—to form a pier. He did not suppose there was any difficulty, but if there was it would be very interesting to know whether Mr. Corbett found any difference in settlement or any cracks occurring between the outside skin and the inner core?

He agreed with all that had been said in reference to distributing rods. It was most essential that these things should be reinforced in both directions. It was quite obvious that the best way of determining the original extent of the secondary part was to calculate the floor slabs as well as concentrated loads, as then one could determine where and how much reinforcement was required.

The Chairman (Mr. E. P. Wells).—He agreed with Mr. Corbett and the other speakers about the excessive load of 2 cwt. per sq. ft. which was asked for by the Manchester city authorities. The author might have gone further and taken a live load of 1½ cwts., and he would have been perfectly safe, as an inclusive load, considering that he had got, as he assumed, factors of safety of 4 to 1, and especially taking into account that there was such an enormous increase of strength in the course of about 12 months after the work was constructed that he could have even gone down to 1¼ cwts. inclusive per ft. super. and then there would have been ample strength in all the construction.

The great reduction in the cost of the building was another matter to be considered, especially when it came to the question of the weights to be carried by the columns and then transmitted to the foundations. It was all very well asking for 2 cwts. per sq. ft., but most authorities had no idea what they were asking for. It was the designer who knew the difference in the cost, especially when he had got to carry the whole of the load.

With reference to the deflection asked for—the $\frac{1}{360}$ of a span—that was a matter which he should never put into a specification. If they had asked for $\frac{1}{1200}$ it would have been nearer the mark. A beam with perfectly free ends, and a depth of about $\frac{1}{16}$ of the span, would give about $\frac{1}{600}$ of the span deflection. If loaded up to an excess of about 50 per cent. beyond the calculated load, when you had continuous construction throughout, if they had beams of about $\frac{1}{20}$, then they would get about $\frac{1}{1200}$. If about $\frac{1}{12}$ or $\frac{1}{14}$, it came to $\frac{1}{2500}$ or $\frac{1}{5000}$ of the span, which was a big difference.

It would have been very interesting if the architect had carried out his original intention of making tests of the work to destruction, especially making a test in the slab, because it would have given him a very fair indication of what had been taking place in the structure itself.

With regard to the test cubes of the concrete where the building was constructed partially in cold weather, what ought to have been done was to keep one set of the cubes exposed to the normal atmospheric conditions, the same as applied to the concrete in the building, and the rest of the cubes kept under laboratory conditions at about 60° F. The laboratory conditions would have given the maximum crushing strength the same as was got in the summer, while the ones kept in the open air would have given the results of the concrete in actual work. Then, that was the criterion as to whether—if the centreing was strong and the loads were applied—there was sufficient compression in the concrete to resist what it had to carry. That was what ought to be done in all cases. The laboratory test would show what it was worth directly the hot weather came, but the open-air test gave the actual conditions on the site.

He was rather surprised, considering the cement that was used and the proportions of the aggregate which were mixed together—the aggregate and the sand—that it worked out a little bit stronger than a 5 to 1 concrete by gauge, and the compressive resistance as low as 108 tons was very different from his experience of the material that he had used in Manchester, and he could not understand how it was that it had run as low as it had done, even after being spread over a period of four months. What he had found was that using that aggregate and the same cement at Manchester, he had generally got about 108 tons in about between five and seven days, and the only point was as to whether the aggregate they used happened to have been exceedingly soft or not. He fancied it would be found that that had been the cause of the mischief, more so than the proportion of the sand, because the author stated that part of his sand was very fine and the other part coarse, and with the graduating of the sand in that way the very best results would be obtained.

With reference to the cutting of the beams, he had a most amusing experience, which really showed the ignorance of some people, of a span of 24 ft. The beam was $\frac{1}{20}$ of the span, as it was required to be exceptionally shallow. He went down to the site, and he found in the centre of the beam a chase had been cut out 4 in. in width by $1\frac{1}{2}$ in. deep, and a leaden pipe 2 in. in diameter built into it, and at the centre a chase was cut out of the beam exposing the reinforcement, and also cut away underneath the full breadth of the beam. The consequence was that the compression member of the beam was reduced by over 50 per cent. It was tested to 50 per cent. in excess, and the deflection was only $\frac{1}{24}$ of an inch. How that took place he did not know ; the concrete was exceptionally good. In the other direction—the span of the floor, which was 5 ins. thick and 13-ft. span—another chase was cut right in the middle of the span, 3 ins. wide by $1\frac{1}{2}$ ins. deep, so that it reduced itself to a beam or a slab with a full span, but with a thickness of 5 ins. less $1\frac{1}{2}$ ins. at the centre, and he thought the deflection in that only amounted to $\frac{1}{16}$ of an inch.

Taking the total cost of the structure as 9·2d. ; for the reinforced work, it worked out at 3d., and for the terra-cotta facing 1·1d. The two combined made 4·1d., which was 44·56 per cent. of the total cost of the work, but all other trades together over the shell worked out at 125 per cent. more than what he might call the building proper did. It appeared to him that all the other trades were very expensive, or the reinforced work had been taken at a very low cost indeed. He should say, judging from what they had seen all round the walls, that for the expensive work that was put in at 2d. or 3d., nearly $4\frac{1}{2}$d. would have been the proper cost, so he was afraid the builders did not make a fortune out of the work.

In conclusion, he moved a hearty vote of thanks to the author for his interesting paper.

Mr. M. E. Yeatman seconded the motion, and it was unanimously carried.

THE LECTURER'S REPLY.

Mr. Corbett, replying to the discussion, agreed that the floor load was absurd and thought it was really simply a matter of nervousness on the part of the local authorities. They did not know where they were with reinforced concrete, and thinking they had better be on the safe side, they had stipulated for the high load.

There were no local by-laws. Everything was in such a very doubtful condition at present that each case had to be submitted to the city authorities on its merits for them to pass or refuse. They had powers in their new Acts to draw up rules for the guidance of reinforced concrete builders, but the rules were not drawn up, and he did not know when they would be.

There was no appeal from the authorities as there was in London, and that was where they were handicapped. Their building laws were not quite as bad as the London Building Act in some ways, but in London they had the advantage of appeal.

The position of the bath on the fifth floor was simply a matter of light and air, and he thought to a large extent the placing of the bath was responsible for their success in the competition for the building. His firm thought that pure air and plenty of light were the first essentials for the athletic section of the building, even though it did cost a little more to get them. Everybody was convinced that it was the right thing to do, and they had received more congratulation in respect of this part of the building than any other. They had ample light and ventilation, and it was practically like going through the exercises in the open air, and the actual cost was very little more than it would have been if they had put the bath, etc., in the basement, while the advantage was very great.

As to the point of deflection, Mr. Workman seemed to think that their gallery test was not a test, because it was not loaded above the ordinary super-load. While Mr. Workman had had much more experience of testing than he (the author) had, he should have thought it was a mere matter of accuracy of the measuring instruments, that whatever load was put on, the beam must deflect. In the case of their 11 ft. 6 in. cantilever it seemed possible that the $\frac{1}{40}$ of an inch permanent deflection might be due to the supporting columns and beams taking their bearings and settling to their work, and the $\frac{1}{40}$ of an inch of temporary deflection was so slight as to be practically negligable. Any floor, however well designed, would be expected to deflect to a slight extent under its normal working load.

He quite sympathised with experts on the question of competition. Architects, however, could not go to simply one firm ; he wished they could, but, much as he wished that, it was only possible in exceptional cases.

In the case of their building, the resident engineer was an employee of the specialist firm, and they included a provisional sum for his salary in their tender, and they paid him themselves direct, and that seemed to be quite a satisfactory way of doing it.

On the subject of the desirability of testing columns he quite agreed, but how were they to do it ? He had worried himself a good deal about how it was to be done, but he could not see how. If they were to be tested at all, the lower part of the column where the load came ought to be tested, and that would cost a small fortune to begin with. It appeared to him the practical difficulties were too great. If they could tell him, he should very much like to know how it could be done ?

He had not noticed any cracks between the core and the outer sections of the columns. The outer section was only a filling outside the core of the column.

They were quite alive to the extra cost due to the 2 cwt. floor-load, but they thought with that they were still materially under what they should have spent with ordinary steel construction, and it was a matter, failing the Court of Appeal, of doing what they were told in the matter of floor-loads, and they had to do it. The 108 tons per sq. ft. on their concrete was the worst they got. They ran up to 231 tons per ft., but the worst was what they had to look at. His own impression was that it was due very largely to cold weather and partly to an accidental excess of sand. It was not the mixed coarse and fine sand, but the rubbings from the stone—the excess of sand. The sand-stone in use was not a particularly hard stone, and coming in the trucks it had got shaken up on the journey and made a certain amount of sand, and in wet weather that was more than in dry, and their difficulty was to get rid of the crushed stone-sand. These poor results were attributable simply to an excess of the crushed stone-sand, which tests proved to be detrimental to the concrete.

As to the amount that the builder made out of the job, he, of course, had no knowledge of this. It was a very complicated work for him to carry out. It was to be hoped, however, that he had not lost on it.

THE REPORTS.

INTERIM REPORT OF THE TESTS STANDING COMMITTEE ON THE TESTING OF CONCRETE, REINFORCED CONCRETE, AND MATERIALS EMPLOYED THEREIN.

1. The Tests Standing Committee of the Concrete Institute held their first meeting on January 26th, 1911, and have held five subsequent meetings.

2. The Committee decided to take up for immediate investigation standard methods of testing concrete, reinforced concrete, and materials employed therein.

3. This interim report deals only with the testing of the materials and specimen pieces of concrete.

Materials.—4. For the purpose of this report the materials employed in concrete and reinforced concrete will be classified under the following headings :

- (*a*) Coarse Material.
- (*b*) Sand.
- (*c*) Cement.
- (*d*) Water.
- (*e*) Steel.

5. This report does not take into consideration, so far as applied to reinforced concrete, any coarse material which does not pass an aperture of $\frac{3}{4}$ in. by $\frac{3}{4}$ in. and which is not retained on an aperture of $\frac{1}{4}$ in. by $\frac{1}{4}$ in. The material used for coarse material generally can be classified under the following headings :

- (*a*) Pit gravel.
- (*b*) Do. crushed.
- (*c*) River gravel.
- (*d*) Do. crushed.
- (*e*) Sea gravel.
- (*f*) Sea gravel crushed.
- (*g*) Crushed rock.
- (*h*) Crushed brick.
- (*i*) Crushed slag.
- (*j*) Clinker and coke breeze.

Classes (*i*) and (*j*) are not recommended as suitable material for reinforced concrete.

Grading Sand and Coarse Material.—6. This Committee is of opinion that to obtain the best results in concrete, the coarse material and sand should be properly graded.

Unfortunately the principle of grading coarse material and sand is very little resorted to, and consequently there are few data on this important subject.

This is now being considered in detail by the Committee, and a further report will be issued in due course.

Voids in Aggregate.—7. The result of a series of tests undertaken shows that the percentage of voids in materials varies according to the different sizes and grading from 35 per cent. to 48 per cent.

Sand.—8. This report does not take into consideration, so far as applied to reinforced concrete, any sand which does not pass an aperture of $\frac{1}{4}$ in. by $\frac{1}{4}$ in., and which is not retained on an aperture of $\frac{1}{50}$ in. by $\frac{1}{50}$ in.

Sand used in concrete work is as follows :

- (*a*) Pit sand (other than that of glacial origin).
- (*b*) River sand.
- (*c*) Sea sand.
- (*d*) Grit or sand from crushed coarse material.

Dust in Sand.—9. It is important that all sand that is not retained on an aperture of $\frac{1}{50}$ in. by $\frac{1}{50}$ in. should be rejected. The following results of tests have been submitted to this Committee as showing the deleterious effect of allowing dust to remain in the sand :

PROPORTION. THREE TO ONE (BY WEIGHT).

Crushing Tests.

British Standard Sand and Cement. Per Square Inch. 28 Days	Crushings from Porphyritic Granite and Blue-grey Whinstone to pass 30×30 Sieve, including all Dust. Per Square Inch. 28 Days.
2,789 lbs.	606 lbs.

Tensile Tests.

7 Days.	28 Days.	7 Days.	28 Days.
182·2 lbs.	234·6 lbs.	53·2 lbs.	104 lbs.

Average of Five Tests at each Period.[1]

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[1] Tests made for Messrs Scott & Fraser by Messrs. D. Kirkaldy & Son.

Coarse Material and Sand Mixed.—10. As will be seen from the accompanying diagram, according to the various proportions of graded coarse material and sand, the percentage of voids varies from 24 per cent. to 30 per cent.

Cement.—11. All cement should be tested and analysed in accordance with the Engineering Standard Committee's latest specification. The Tests Standing Committee of the Concrete Institute strongly recommends that in addition the crushing strength of the cement should be ascertained in the following manner :

Cubes for Crushing Test.—12. Cubes mixed in the proportion of 3 parts of standard sand to 1 part of cement, by weight, shall be made up and treated in all respects similar to briquettes of sand and cement for the tensile test, but the test specimens for crushing to be 3-in. cubes. The crushing strength shall be not less than ten times the tensile strength at 28 days required by the British Standard Specification.

Water.—13. This Committee is of opinion that it is not advisable to define the proportion of water to be used in making up concrete or test specimens of cement and concrete, as this quantity must be more or less dependent on the variations in the weather and the nature of the coarse material and sand used in each particular case ; but it is generally considered that the concrete should be mixed to a plastic state. though not so wet as to allow any dripping of the cement, water, and sand.

Steel.—14. The following tests are recommended for all steel work for use in reinforced concrete.

15. The steel shall attain an ultimate tensile strength of not less than 60,000 lbs, per sq. in.

16. The steel shall withstand a stress of at least 34,000 lbs. per sq. in. before showing any appreciable permanent set.

17. The contraction of area at fracture shall be not less than 45 per cent.

18. (Or) The elongation in the case of bars of 1-in. diameter and under shall be not less than 25 per cent. measured on a length equal to eight times the diameter of the bar tested.

The elongation shall be measured in the case of bars over 1-in. diameter on a length equal to four diameters of the bar, and shall be not less than 30 per cent.

19. All steel shall stand bending cold to an angle of 180° around a diameter equal to that of the piece tested, without fracturing the skin of the bent portion.

20. The steel shall be free from scabs and flaws.

Crushing Resistance of Concrete.—21. For the purpose of ascertaining the crushing resistance of concrete the following particulars shall be complied with :

(*a*) All test pieces shall be 4-in. or 6-in. cube.

(*b*) Number of test specimens for each test shall be six.

(*c*) Three cubes shall be made in the laboratory and three for each test shall be made on the works.

(*d*) The cement for each series of cubes shall be taken from the same consignment.

(*e*) All laboratory-made test cubes shall be made as far as possible on practical lines, so that the results of the tests shall be such as can be reasonably expected from concrete in the actual work with proper care and attention.

(*f*) Specimen cubes from the works shall be made with concrete taken from the actual mixing platform ; the concrete used for the specimen cubes shall be taken from the various batches of concrete prepared for use in the works.

(*g*) In all cases specimen pieces shall be made in metal moulds, and the concrete worked in by " punning " and " tamping " and afterwards gently rammed.

Particulars to be Taken or Ascertained.—22. The following particulars shall be taken or ascertained of the materials used in the test specimens of the concrete :

(*a*) Full test on cement as specified in Clauses 11 and 12.

(*b*) The coarse material and sand for the laboratory tests, which is to be taken from bulk as delivered to the works, shall be sieved to the following degrees and the voids ascertained of (1) the whole and (2) of each separate grading :

Coarse Material.

To pass an aperture of—	To be retained on an aperture of—
$\frac{3}{4}$ in. by $\frac{3}{4}$ in.	$\frac{5}{8}$ in. by $\frac{5}{8}$ in.
$\frac{5}{8}$ in. by $\frac{5}{8}$ in.	$\frac{1}{2}$ in. by $\frac{1}{2}$ in.
$\frac{1}{2}$ in. by $\frac{1}{2}$ in.	$\frac{3}{8}$ in. by $\frac{3}{8}$ in.
$\frac{3}{8}$ in. by $\frac{3}{8}$ in.	$\frac{1}{4}$ in. by $\frac{1}{4}$ in.

Sand.

To pass an aperture of—	To be retained on an aperture of—
$\frac{1}{4}$ in. by $\frac{1}{4}$ in.	$\frac{1}{8}$ in. by $\frac{1}{8}$ in.
$\frac{1}{8}$ in. by $\frac{1}{8}$ in.	$\frac{1}{16}$ in. by $\frac{1}{16}$ in.
$\frac{1}{16}$ in. by $\frac{1}{16}$ in.	$\frac{1}{32}$ in. by $\frac{1}{32}$ in.
$\frac{1}{32}$ in. by $\frac{1}{32}$ in.	$\frac{1}{50}$ in. by $\frac{1}{50}$ in.

(*c*) The proportion of each grading to the whole.

(*e*) The specific gravity of the coarse material and sand.

(*b*) The exact dimensions of specimen cubes.

(*c*) The weight per cubic foot of all specimens immediately before testing.

(*f*) The testing of concrete specimens shall be conducted on three laboratory specimens and three specimens made on the work (see Clause 21), and shall be tested at the following periods :

Minimum Tests.	7 days	***Medium Tests.***	7 days
(Recommended as the least that should be undertaken.)	28 ,,	(Recommended to be undertaken wherever possible.)	28 ,,
	55 ,,		56 ,,
	90 ,,		90 ,,
	6 months		9 months
	12 ,,		1 year
			2 years

Maximum Tests.	7 days	1 year
(Recommended for extensive structures and research.)	28 ,,	2 years
	56 ,,	3 ,,
	90 ,,	4 ,,
	6 months	5 ,,
	9 ,,	

All specimens shall be kept in air after mixing and slightly damped for the first seven days.

All cubes made up on the works shall be forwarded to the laboratory on the fifth day.

After the expiration of seven days specimens shall be kept under cover for the purpose only of protection from the direct action of rain and direct sunrays.

Cost of Testing.—23. The Committee is of opinion that for the purpose of providing for the cost of testing a provisional sum should be included in all contracts where such testing will be required, this being the most satisfactory and fairest way to all parties concerned.

24. Members of the Institute are invited to forward the Committee particulars of any tests which they may have available.

(Signed) WILLIAM G. KIRKALDY,
Chairman of Tests Standing Committee.

(Signed) A. ALBAN H. SCOTT,
Hon. Secretary of Tests Standing Committee.

REPORT OF THE REINFORCED CONCRETE PRACTICE COMMITTEE, EMBODYING SUGGESTIONS ON "THE STANDARDISATION OF DRAWINGS OF REINFORCED CONCRETE WORK."

THE Reinforced Concrete Practice Committee of the Institute also submitted a report on "The Standardisation of Drawings," a summary of which we give below. In this connection we would refer our readers to an article, containing practically identical proposals, which appeared in our February, 1910, number, entitled "Standard Methods for the Preparation of Reinforced Concrete Drawings." The discussion of this and the preceding report was postponed till the winter session.

Scales.—In connection with the scales to be used for drawings, inquiry forms were sent to all the best known contractors and specialists undertaking reinforced concrete construction, but only a small number returned these forms filled in. No adequate classification of the practice among the contractors could therefore be arrived at from these inquiry forms, and the matter has therefore been considered from what is generally known of the practice of various specialists.

A great number of scales have been, and are, employed by architects and engineers, but only a few are generally adopted. These few can be used to fulfil almost all requirements. Of course a scale is fundamentally chosen to suit the conditions of the extent of the job, and the size of the drawing paper, having due regard to clearness.

After comparing the various scales in general use, the Committee suggested the following as the best scales for standardisation for the preparation of drawings for reinforced concrete work :

For general drawings :

Showing schemes in outline without detailing the reinforcements : $\frac{1}{8}$-in. scale ($\frac{1}{16}$-in. scale to be substituted for $\frac{1}{8}$-in. scale for large jobs).

For detail drawings :

For framing plans and slab reinforcements : $\frac{1}{8}$-in. scale.

For elevation of beams, etc., and general detail drawings : $\frac{1}{2}$-in. scale ($\frac{1}{4}$-in. scale to be substituted for $\frac{1}{2}$-in. scale for large members).

For sections of beams, etc. : $1\frac{1}{2}$–in. scale.

For large details of intricate work : 3-in. scale.

All dimensions should be figured on the plans and nothing left to be scaled.

It is suggested that the size of sheets upon which drawings are made should be standardised. For general purposes two sizes are advocated—namely, 40 in. by 27 in., and 20 in. by 27 in. Larger sheets would be of the same depth, 27 in., but of greater length. These are measurements within the margin line, which latter should be ruled upon the tracing cloth, and photographic prints should be trimmed to this ruled margin line.

Indicating the Reinforcements.—As regards the indication of reinforcements upon the plans, it is suggested that it will be found convenient generally on $\frac{1}{2}$-in. scale drawings to show main bars by means of thick solid lines, secondary bars by means of lines of medium thickness, and the outlines of the concrete and other work by means of thin lines. Working with this small scale it may often be found an advantage to omit the reinforcements in adjoining members—as, for instance, the bars in floor slabs when drawing elevations of T-beams—as otherwise the main reinforcements may be obscured.

In $1\frac{1}{2}$-in. and 3-in. scale drawings it will often be found advisable to show bars, when not of very small size, by means of double lines. The lines should, however, be strongly drawn.

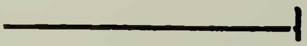
Sections will often require picking out. Many draughtsmen indicate the concrete by marks intended to show stones, as it is claimed that etching takes longer to do and requires great care to ensure the lines being spaced regularly apart, without which the appearance is not good. There seems justice in this contention, and such marking for showing concrete is advised.

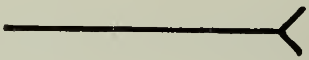
Reinforcements shown in section should always be blacked in. Too much emphasis cannot be given to the reinforcements, as the drawings are specially intended to indicate them.

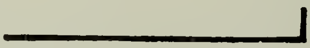
Shading of bars should not be employed on anything less than half full-size drawings.

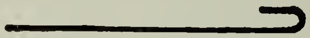
Ink and Washes of Colour.—Waterproof black ink should always be employed, and lines should be strong and solid. No washes or shading should be employed, because the former come out as solid patches by ordinary methods of reproduction; and the latter, where drawings are reduced in process reproduction, tends to clog and produce solid patches as before mentioned.

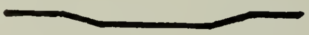
Stops to Ends of Lines.—In showing reinforcements on plans and elevations to $\frac{1}{2}$-in. scale it is necessary to employ some form of stop to the ends of each line to show where the ends of a bar terminate. The following is suggested as being clear, easily and quickly drawn, and as also avoiding any necessity for putting wording upon the drawings to state how the ends are to be dealt with :

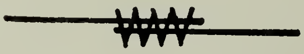
Ordinary cut ends thus ... 

Fishtail ends thus ... ... 

Turned-over ends thus ... 

Hooked ends thus ... ... 

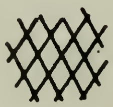
Cranking thus ... ... 

Wired junctions thus ... 

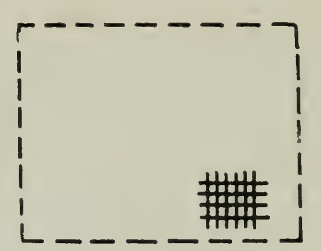
Writing and Descriptions.—The following standard list of abbreviations to be written on drawings is advocated :

	Bars ...	*b*
	Top bars	*t b*
	Cranked bars	*c b*
	Distributing bars	*d b*
Steel Structural Shapes	Rounds	ø
	Squares	□
	Tees ...	T
	Angles	L
	Joists...	I
	Channels	⊔
	Flats or hoops	*f*
	Special bars ...	Initial letter (or letters) of trade name.

Sheet Meshes.—In sections — — — — — — —

On plans ... ... 

The mesh to be drawn on a part only of each bay, the boundary line of each bay being dotted thus :



Pitch or spacing (as in columns or slabs)	*p*
Feet	′
Inches	″
Square inches	in.²
Cubic inches	in.³
Pounds per sq. in.	lbs./in.²
Imperial wire gauge	I.W.G.
British standard section	B.S.S.

Examples :

1″ □	1-in. square bar.
1″ Ø 3″ *p*	1-in. round bars at 3-in. pitch.
1″ *t*	1-in. flat.

Columns and Beams.—It is suggested that the position of the reinforcements in columns need not be indicated on every floor plan, it being only necessary on the larger scale drawings to show the position of beams, the outline of the columns being merely dotted in. This omission of the column bars makes for clearness. On ⅛-in. scale drawings the columns may be blacked in solid.

The columns throughout the structure should be detailed as a complete series, the outlines only of connecting beams being shown, as thereby the reinforcements can be more clearly and conveniently shown in their proper relation one to another. If thought desirable, connections can be detailed to 1½-in. or 3-in. scales.

On plans the outlines of secondary beams should butt against the outlines of main beams.

Walls standing upon any floor and carrying beams over, if shown upon the same plan as the beams, may be distinguished by etching.

The plan of any floor should be drawn looking up—*i.e.*, showing the beams and floor over, so that the " First Floor Plan " will show the second floor.

In ⅛-in. scale drawings the sections of floor slabs and beams can be blacked in solid.

Lettering.—Titles should be put in the lower right-hand corners of all drawings, together with serial drawing numbers, this position being best for reference when drawings are kept either in rolls or flat in drawers.

As regards the lettering upon drawings, this should be large and open.

In American engineering practice some general standard style of lettering is apparent. Whatever lettering is adopted, it should be neat and easily drawn. An alphabet is put forward as being likely to meet all requirements.*

Colouring Drawings.—It is inadvisable to colour drawings for reinforced concrete, and in drawing details, except of large size—*i.e.*, 3-in. scale or half-full-size, it is not advisable to dot in the concrete in any way, as if at any time these are reproduced in catalogues or newspapers the great reduction that must occur will run these closely-spaced marks together and clog the work or perhaps make a solid patch of ink. If, however, it should be found necessary to employ colours to distinguish various parts of the work, it should be recollected that all colours, except faint blue, by ordinary photographic reproduction come out the same as though they were in solid black ink. Therefore, if any wash is employed where reproduction is desired, it should be a very faint blue.

A list of colours used upon architectural drawings where these have to be coloured was added, but as this is exactly similar to the one in our issue of February, 1910, we refer our readers to that number.

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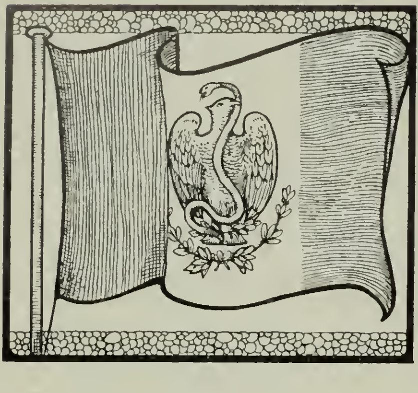
* A reproduction of this alphabet will be found on page 94 of our issue of February, 1910.



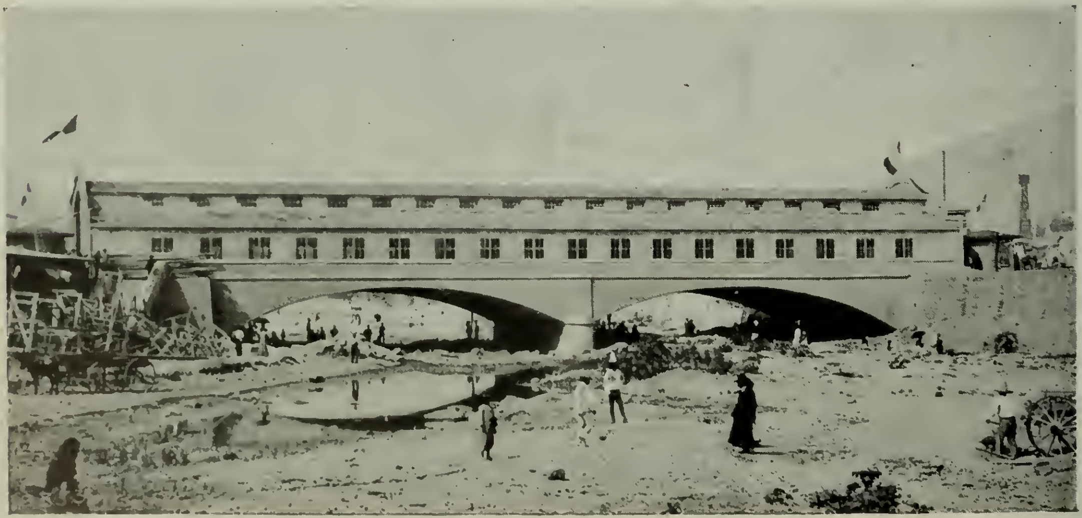
SOME EXAMPLES OF CONCRETE & REINFORCED CONCRETE WORK IN MEXICO.

It is with great pleasure that we publish an article dealing with the development of concrete and reinforced concrete in Mexico. Remarkable progress is being made in all constructional work in that country, and concrete work is finding great favour there.—ED.

THE MARKET HOUSE BRIDGE AT MONTERREY, MEXICO.

A NOVEL application of reinforced concrete is shown in the accompanying views of a market house in the City of Monterrey, Mexico, supported on a reinforced concrete bridge of two arches of 74 ft. 2 in. span each, across the Santa Catarina River. The site was formerly occupied by a wooden market building on a through truss bridge of steel of two 75 ft. spans. The old bridge and market house were destroyed by fire in January, 1908, and in rebuilding the structure it was decided to use reinforced concrete throughout as being non-combustible.

The old bridge had been supported on piers and abutments of cyclopean masonry. The stone pier was wrecked to a level of 1 ft. above the bed of the river, and the new pier 7 ft. thick at the base and 6 ft. thick at the springings was erected on this foundation. The abutments were wrecked to 6 ft. below the bed of the stream, and the new abutments built upon them as a foundation, but extending 6 ft. back of the old stone abutments which were 7 ft. thick. The new abutments were thus 13 ft. thick, supported on compact gravel at the rear.



THE MARKET HOUSE BRIDGE, MONTERREY, MEXICO.

Large rocks from the wrecked masonry were embedded in the concrete of the new abutments, and spaced not nearer than 12 in. apart horizontally and 3 in. vertically. The concrete throughout the bridge was composed of one part cement, $2\frac{1}{2}$ parts of sand, and 5 parts river gravel.

The stability of the 13-ft. abutment for 74-ft. span was a question of considerable discussion, since, as is always the case, its dimensions are governed largely by the conditions of the foundations, which may vary greatly. When centres were struck the deflection was not greater than $\frac{3}{32}$ in. on either arch, and no cracks of any kind occurred, except as intended at the expansion joints at each end of the span, thus establishing the fact that for the given foundations the abutments had been properly proportioned.

The arches were reinforced with $\frac{3}{4}$-in. steel rods spaced 12 in. centre to centre arranged in one series, but crossing the arch ring at alternate points, one-third, one-half, and two-thirds the distance from springing to crown. Alternate rods are anchored in the face and back of abutments. The transverse reinforcement consist of $\frac{3}{4}$-in. rods spaced about 4 ft., and extending upwards into the spandril walls, which are also reinforced longitudinally in the coping from expansion joint to expansion joint.

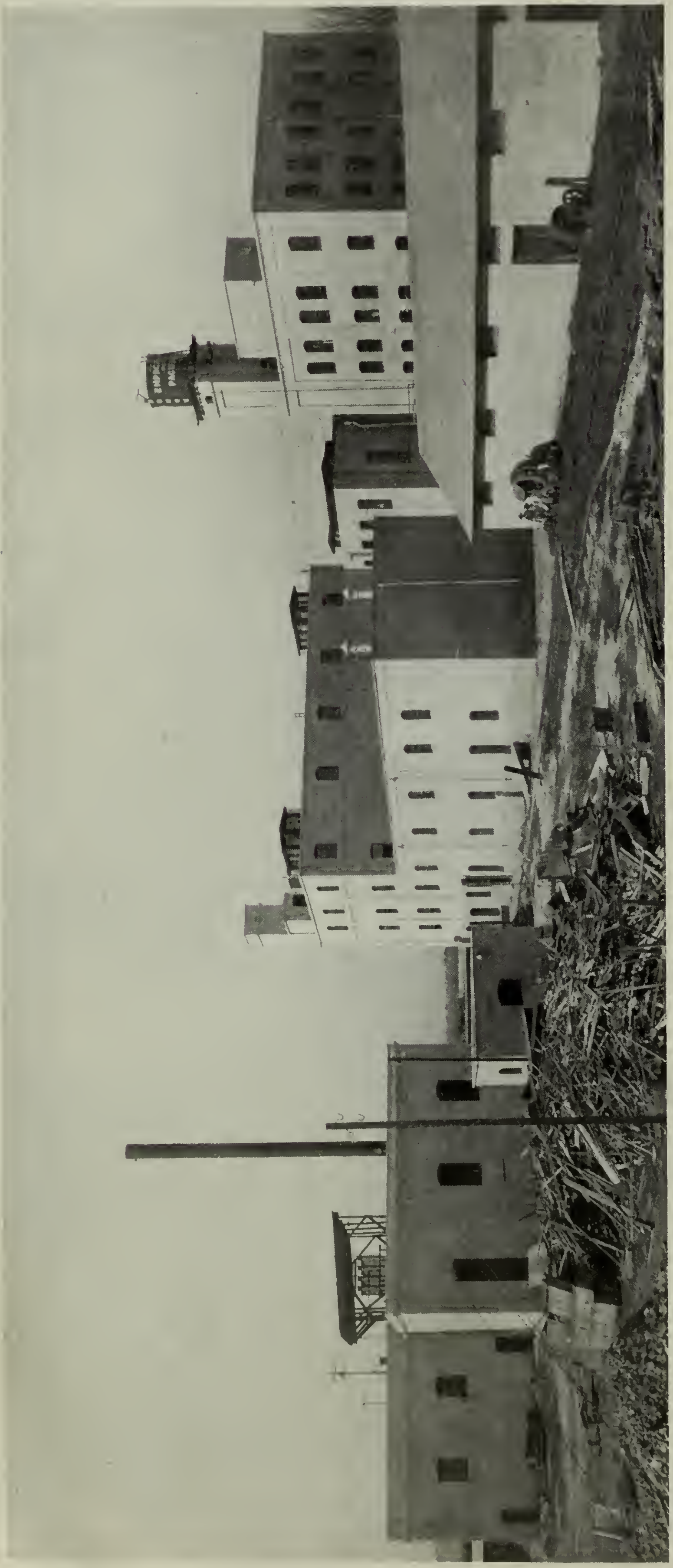
The centering was extremely light, made possible by the use of columns consisting of 2 in. by 6 in. and 2 in. by 8 in. timbers in pairs arranged in the form of a T, that is, with the major dimensions of the 2 in. by 6 in. transverse to the major dimensions of the 2 in. by 8 in., and made to act together as a column by wrapping at intervals of 3 ft. or 4 ft. with No. 10 wire. No wedges were used for striking centres, but when the time arrived to strike centres the wires were cut, allowing each member of the compound column to buckle separately, thus subjecting the arch to stress very gradually.

The arches were concreted in longitudinal rings continuous from abutment to middle of pier, and the spandril walls connected monolithically with the ring to avoid the unsightly ragged joint that otherwise would appear above the arch ring. Immediately after completion of the arch the earth fill was tamped into place to the level of the roadway, and after the fill was completed, and but eight days after the completion of the arch rings, the centres were struck.

The centres were thus removed before the completion of super-structure. This step not only constitutes a desirable feature in the construction of any arch, but was quite indispensable in this structure. Thus, had the concrete market house been completed before striking centres, it would undoubtedly have been seriously cracked and strained by the settlement of the arches, even though that was but $\frac{3}{32}$ in. at crown.

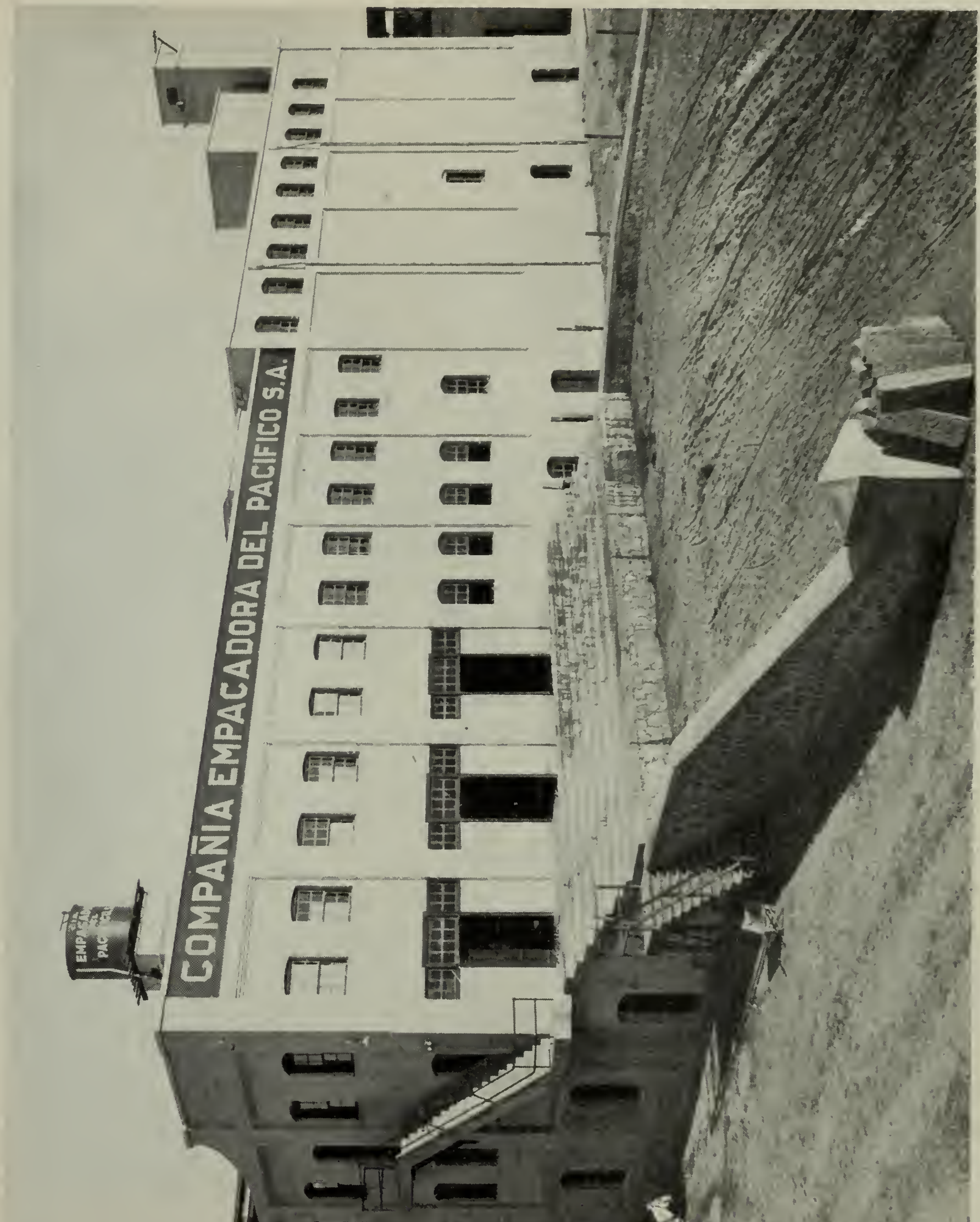
The expansion joints consist simply of a vertical plane of separation in the spandril wall at each end of the span. To prevent seepage from the earth-fill discolouring the face of the spandrils a vertical groove is formed with an outlet below to serve as a drain. The expansion joints opened about $\frac{1}{16}$ in. when centres were struck.

The general construction of the market building is shown in the accompanying photograph. This building is 200 ft. long by 52 ft. wide. The height of the out-



Pacific Packing Company's Offices, Guadalajara, Mexico.

side walls is 10 ft. 6 in., and the highest point of the monitor is 25 ft. 6 in. above the floor. A clear roadway of 19 ft. 6 in. is left through the centre of the bridge. The floor space on each side of this roadway is divided into 20 market stalls, each 10 ft. wide by 16 ft. 3 in. long. The building is entirely of reinforced concrete, with the exception of the wooden counters, the Expanded Metal screens in the front of the stalls and the windows. The walls are 3 in. thick, reinforced both horizontally and vertically with $\frac{5}{16}$-in. plain round rods, 12 in. centre to centre. The outside walls have no studding or transverse supports other than the partition walls between the rooms. The roof slab is reinforced with No. 24 gauge Expanded Metal, and is supported on 3 in by 8 in. concrete purlins placed 5 ft. $1\frac{1}{2}$ in. centre to centre, and reinforced with $\frac{5}{16}$-in.



Pacific Packing Company's Offices, Guadalajara, Mexico.

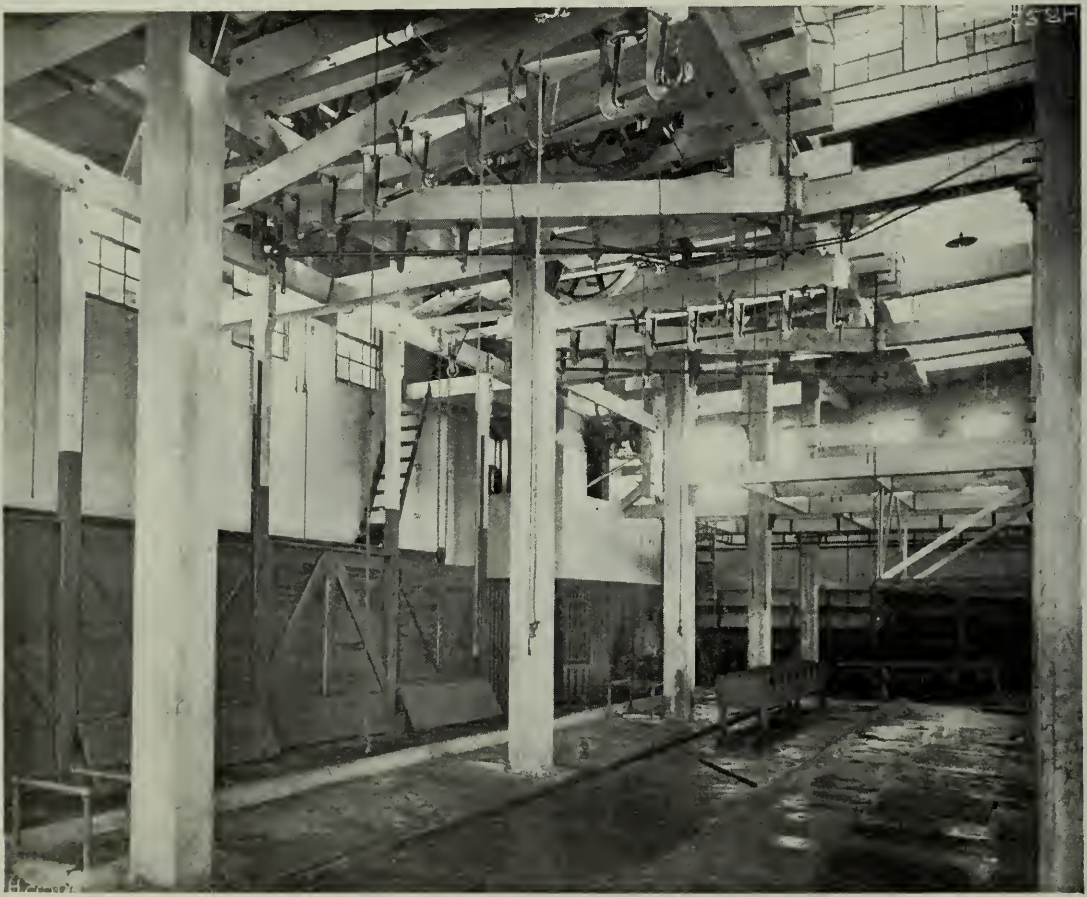
rods. These purlins were made in wooden forms on the ground and hoisted to position. The window frames are made of 3-in. channels and are bent over the roadway to give form to the intrados of the concrete arches supporting the monitor

Work was commenced April 1st, 1908, and the bridge proper was completed June 20th, 1908. The building was commenced ten days later, and completed October 1st. The contractors of the bridge were Topeka Bridge and Iron Co., of Kansas.

Alfred Giles, of Monterrey, Mexico, and San Antonio, Texas, from whom these particulars were obtained, was the architect.

PACIFIC PACKING CO.'S OFFICES, GUADALAJARA, MEXICO.

ANOTHER example of the different uses to which reinforced concrete has been put in Mexico will be seen from the accompanying illustrations of the new plant for the "Pacific Packing Co.," of Guadalajara, Mexico.



View of Interior Construction.
PACIFIC PACKING COMPANY'S OFFICES, GUADALAJARA, MEXICO.

The foundations were of stone laid in mortar or cement where necessary. Exterior walls are of brick laid in mortar, plastered outside with lime and inside with cement.

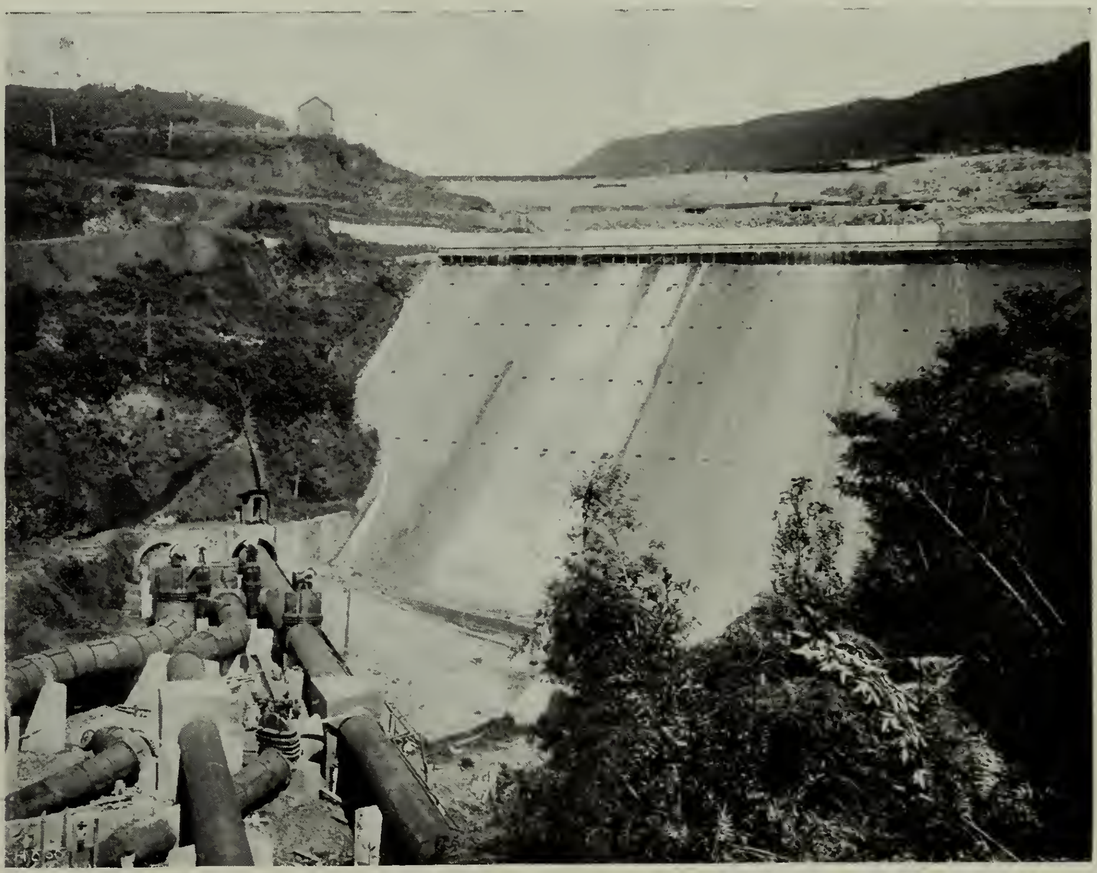
The columns, girders, floors, and roofs are constructed of reinforced concrete. The columns are from 12 in. by 12 in. to 20 in. by 20 in., and from 10 ft. to 21 ft high in each storey. The girders are from 10 in. by 20 in. by 16 ft. to 20 in. by 24 in. by 18 ft., the largest girders being 14 in. by 36 in., with 26-ft. span. Floor slabs are 5 in. to 8 in. thick.

The total area in floors and roofs is 59,720 sq. ft.

The mixture used was 1 cement, 2 sand, and 4 crushed stone. The cement used in the construction of all reinforcement was the "Gibbs" brand of the Associated Portland Cement Manufacturers. The steel reinforcement was Johnson corrugated bar type from the Monterrey Steel Works. We are indebted to Mr. H. H. Hinkle, vice-president and manager of the Pacific Packing Co., for our particulars and photographs.

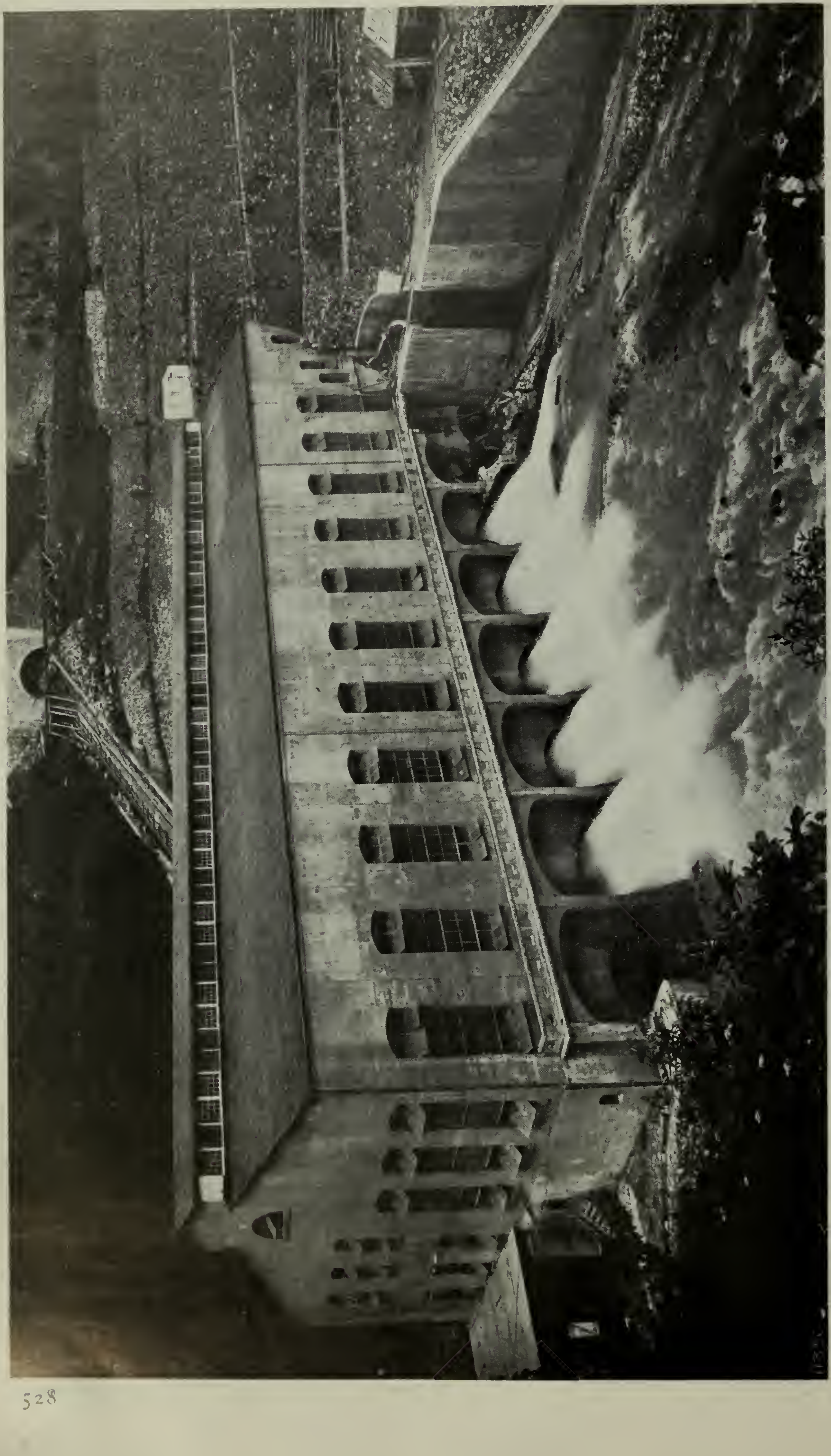
HYDRO-ELECTRIC POWER PLANT, NECAXA, MEXICO.

One of the most important projects recently carried out in the development of Mexico is the construction of the enormous hydro-electric power works at Necaxa, which have changed the state of affairs in that country, and have done wonders in improving industrial conditions. Millions of money have been spent on this project to provide a steady flow of water.

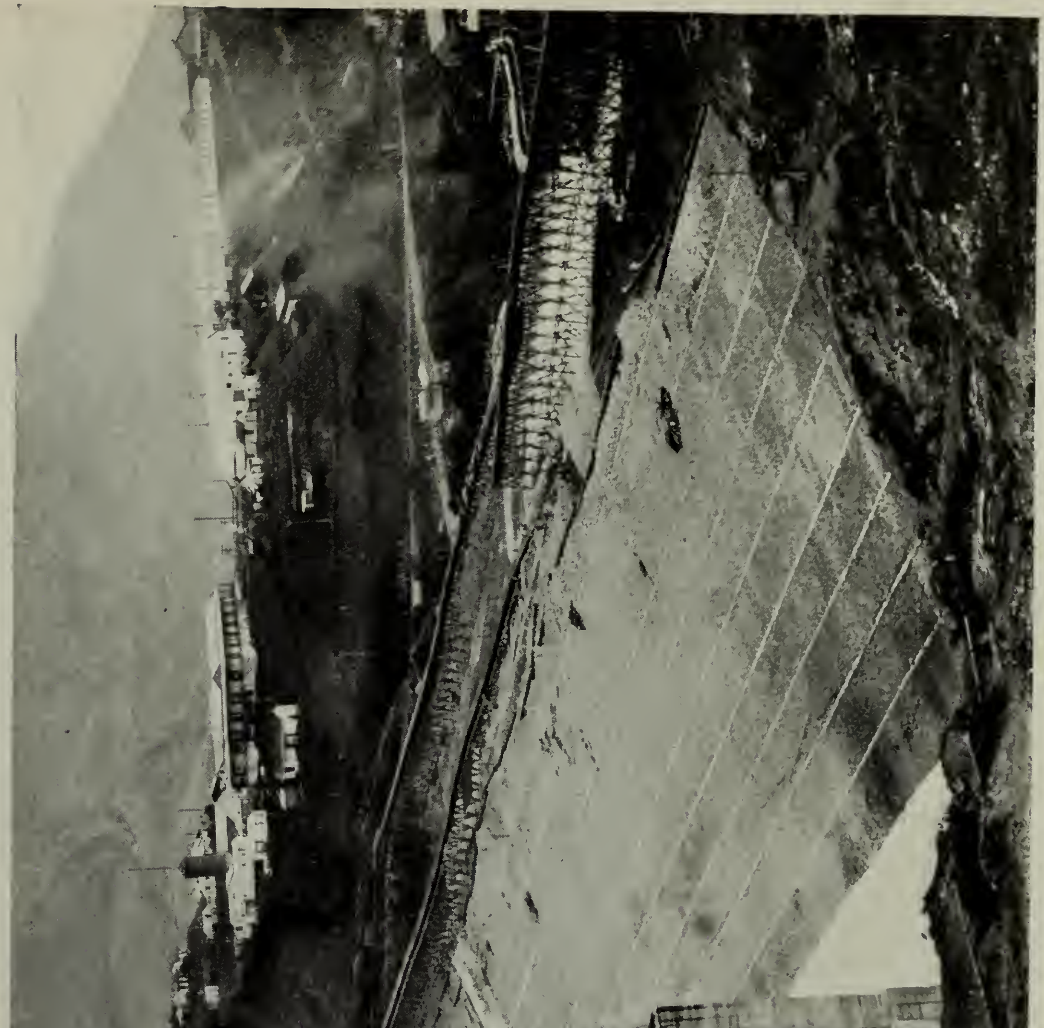


Finished Portion of Dam No. 2.
Hydro-Electric Power Plant, Necaxa, Mexico.

The original plan was to provide a hydro-electric plant to utilise the natural flow of the Necaxa River at a point where two falls gave a combined drop of 1,400 ft., but it has now grown to include the diversion of a dozen other rivers which have been brought into the Necaxa basin by a series of tunnels. An immense dam at Necaxa stores 44,000,000 cubic metres of water during the rainy season.



View of Power House.
Hydro-Electric Power Plant, Necaxa, Mexico.



View of Dam No 2 and Power House in distance
HYDRO-ELECTRIC POWER PLANT, NECAXA, MEXICO.

The Necaxa plant furnishes 50,000,000 horsepower to Mexico and El Oro. The dam, when completed, will have a height of 194 ft.

The main power house is a steel framed and concrete structure with concrete foundation. It is 65 ft. high above the floor line, 214 ft. wide, and 265 ft. long, and six large generators are now working on its broad floor.

The power is generated in six vertical units, operated in individual rooms made of cement.

The whole of this enormous undertaking was carried out by the Mexican Light and Power Co., of Necaxa, and we are indebted to their chief engineer, Mr. H. Kearney, for our photographs. The cement used in the construction of the dam and power house was "Gibbs" brand, supplied by the Associated Portland Cement Manufacturers (1900), Ltd.

MEXICO CITY'S NEW WATERWORKS.

Another large waterworks system in Mexico, in the construction of which concrete played an important part, is the new waterworks for Mexico City. This work has been in progress since 1903, and is a triumph of engineering skill. The sources from which the water to supply the demands of Mexico City, with its population of over 400,000, was obtained previously were found to be unsuitable and inadequate, and the system of distribution was also deficient in many respects. It was therefore determined to sink huge wells at four of the most copious springs, construct a main conduit connected with the wells, pump the water into the conduit which leads to the hill Molino del Rey, about four miles west of the city, and then pump it into four large reservoirs on the top of the hill, at such an elevation that by the simple force of gravity the water will flow through the distribution pipes from the reservoirs to the city. The wells were lined with concrete.

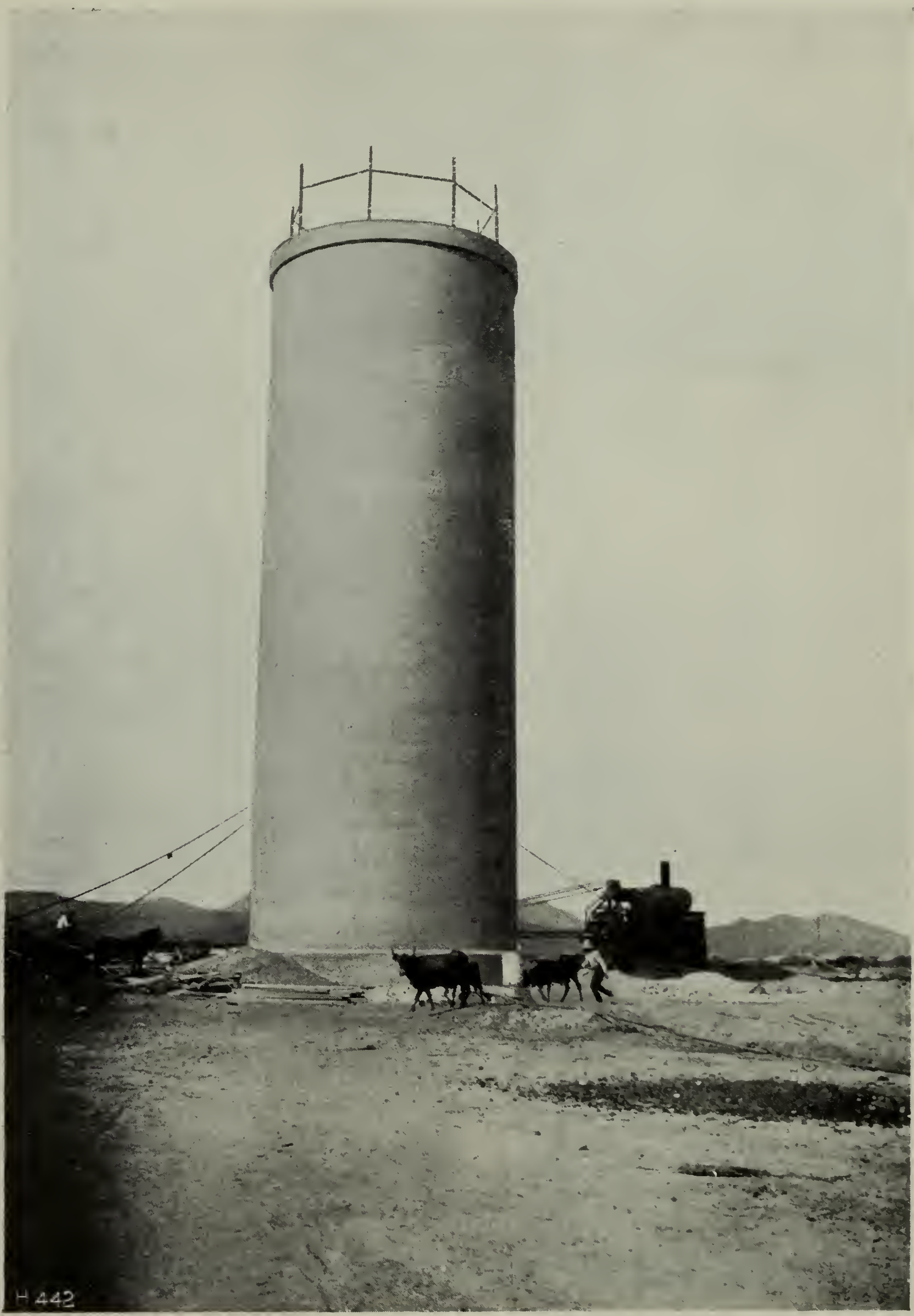
The main conduit to Molino del Rey will be about 16¼ miles in length. It is about 10 ft. in diameter, and is constructed of concrete reinforced by a mesh of steel bars and rods. This conduit will have a capacity to carry 40,100,000 gals. of water every 24 hours. One of the most important features of the work was the construction of the great subway for the reception of the large water mains. This tunnel is about 10 ft. in width. The side walls of reinforced concrete are about 4 in. thick, and the roof 6 in. But the finest portion of the work consists of the four great reservoirs on the hill of Molino del Rey. Each is 162 ft. in diameter, and about 23 ft. in depth. They will be covered by a cement roof supported by massive pillars over 16 ft. apart.

REINFORCED CONCRETE WATER STANDPIPE IN EMPALME, MEXICO.

A further application of reinforced concrete in Mexico is shown in our illustration of the standpipe erected by the Southern Pacific Railroad Co., of Mexico, at Empalme, Sonora, Mexico. The capacity of this is 480,000 gals.

Sixteen-inch concrete piles were driven for the foundations, and corrugated bars were used for the reinforcement. The base of the water tower is octagonal shaped, and is 38 ft. across. The water tower itself is round, and is 30 ft. inside diameter, and 30 ft. 10 in. in diameter to the outside face. The height of the tower is 90 ft.

All reinforcing rods were securely fastened to vertical rods by soft iron wire at points of contact to prevent displacement. The shell and floor were made of concrete in the proportions of 1 : 2 : 3½.



CONCRETE MIXERS.

In some of our former issues we have been publishing articles on different appliances for concrete mixing, and the present pages are a continuation of the particulars presented, and are based on data kindly put at our disposal by the makers of the respective appliances, and indicate their views as to their efficiency.

The whole question of using mixers requires far greater attention than at present is accorded to this important subject. The economy of concrete and reinforced concrete work largely depends on the suitability of the machinery employed. Thus these contributions merit careful consideration.—ED.

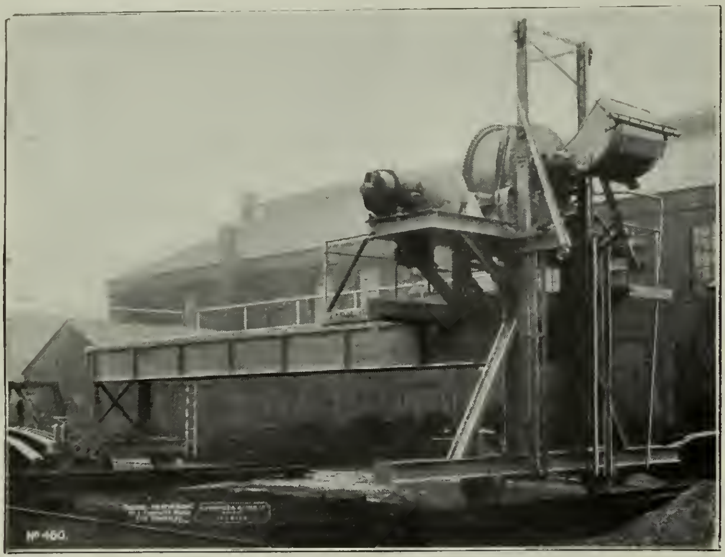


Fig. 6. Ransome Mixer Mounted on a Travelling Gantry for Admiralty Works, Dover.

RANSOME MIXERS.

The Ransome mixer is one of the best known and most up-to-date of the many machines for mixing concrete which are at present on the market. The drum is designed to be easily erected on the frame, which is made of English steel throughout, and can readily be lifted off for transit. Very rapid and thorough mixing is ensured by the special design of the mixing blades. The mixing is both longitudinal and lateral, so that every portion of the batch is intermingled, which is a most important point, as the strength of the concrete depends on the thoroughness with which the materials are mixed. The machines are fitted with a hopper which measures the exact amount of aggregate for each batch. An automatic water-tank for gauging the exact amount of water for each batch is also attached. The process of discharging the mixer is also a very simple operation, which is carried out by means of a chute worked instantaneously by hand.

Tests made on Admiralty work have proved that the Ransome is capable of mixing a batch of 20 cu. ft. perfectly in 30 seconds.

An illustration of a new Ransome hand mixer, which is of the paddle type and has a batch of 2 cu. ft., is shown in *Fig.* 1. The paddles are easily turned

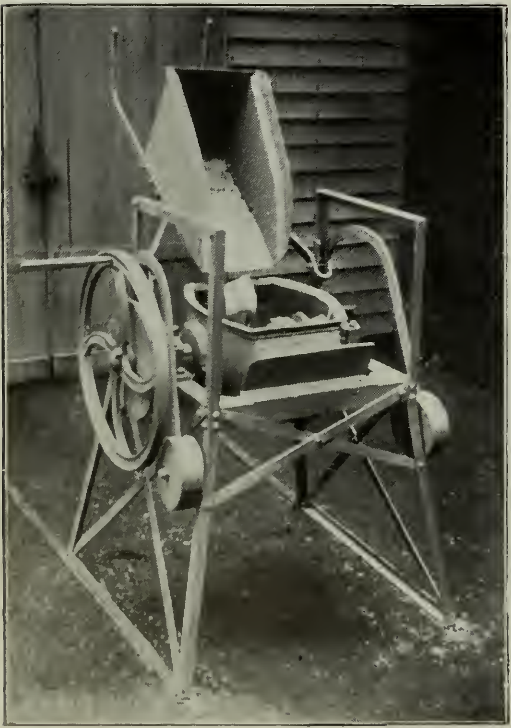
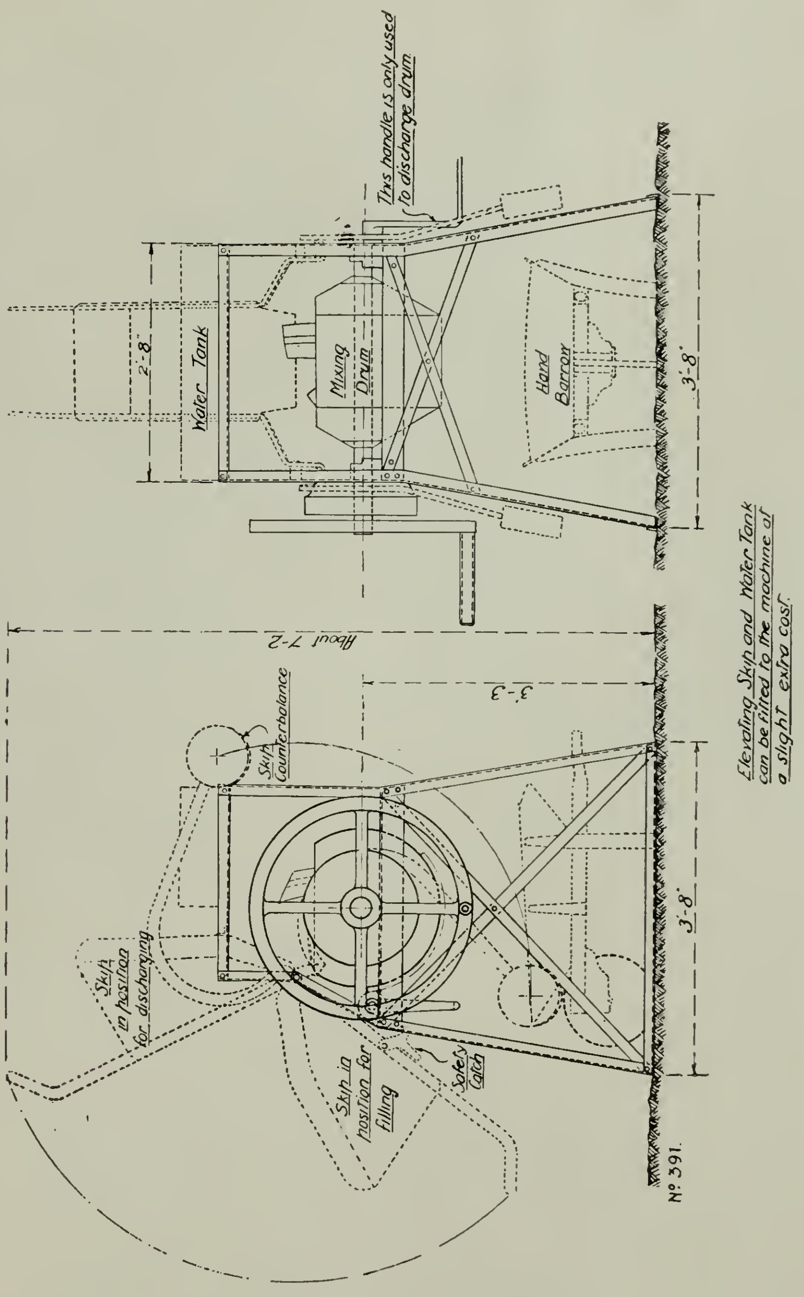


Fig. 1. Ransome Hand Mixer.

by one man when the full batch is in the drum, and an arrangement of flat steel springs is provided to prevent any possibility of the jamming of stone between the blades and the drum plates. The blades keep the mixer absolutely clean, and the drum is of such dimensions as to allow discharge into a standard navvy barrow without spilling. For discharging purposes the drum is tilted by the man who is wheeling the mixed concrete.


This handle is only used to discharge drum
Water Tank
Mixing Drum
Hand Barrow
2'-8"
3'-8"
About 7'-2"
3'-3"
Skip Counterbalance
Skip in position for discharging
Skip in position for filling
Safety Catch
3'-8"
Nº 391.

Elevating Skip and Water Tank can be fitted to the machine at a slight extra cost.

Fig. 2. Method of Mixing with Ransome Hand Mixer.

A very clear idea of the method of mixing with the Ransome hand mixer will be seen in *Fig.* 2. The capacity of this machine is 15 cu. yd. to 20 cu. yd. per day of 10 hours.

In *Fig.* 3 we show a No. 5 mixer actually in operation at Rosyth in the blockyard. Altogether six of these mixers have been supplied for this one contract, and one No. 4 machine. They are guaranteed to give an output of

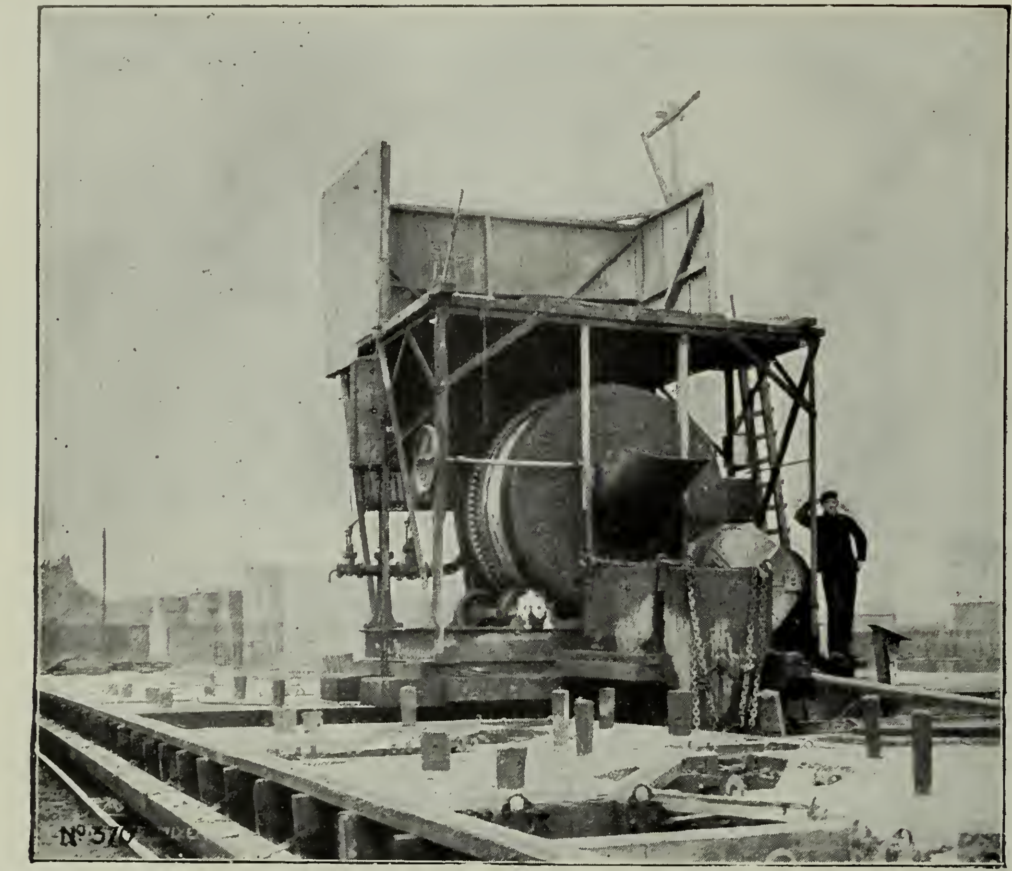


Fig. 3. No. 5 Mixer in Operation at Rosyth.

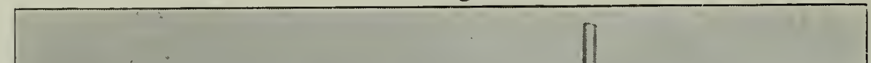


Fig. 4. No. 1 Mixer for Street Work.

660 cu. yd. per day, but this quantity can quite easily be doubled where efficient methods of feeding and removing the mixed concrete are employed.

A type which is particularly suitable for street work, or for any contract where the concrete is spread over a large area, thus necessitating the constant moving of the mixer, is coupled direct to a totally enclosed paraffine engine, and mounted on road wheels so that it can easily be moved about from one side of the street to the other. The total weight is as low as possible, the overall dimensions of the machine are extremely limited, and the oil engine, which works on either petrol or ordinary paraffine, is simple to work, and can be started up at any moment. The actual mixer illustrated in *Fig.* 4 was supplied to the order of the India Office.

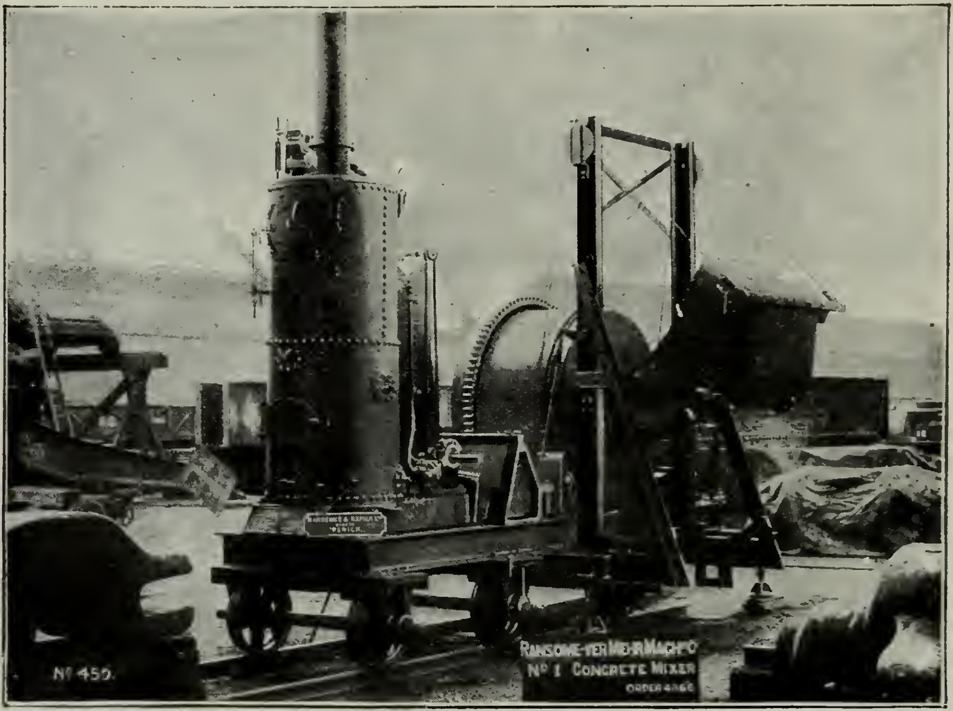


FIG. 5. No. 1 MIXER, USED IN CONSTRUCTION OF THE LEIGHTON RESERVOIR.

Fig. 5 shows a combined plant supplied to the order of Messrs. Harold Arnold & Son, of Doncaster, for use in the construction of the Leighton reservoir. This was a No. 1 mixer, with Ransomes, Sims & Jefferies' steam engine and boiler, elevating hopper, and mounted complete on 3-ft. gauge rail wheels.

A special plant made for the British Admiralty for use at Dover for blockyard purposes will be seen in *Fig.* 6. This consisted of a travelling gantry, on which was mounted a No. 1 mixer, driven by a totally enclosed electric motor, and fitted with elevating hopper. The gantry was arranged to travel along the blockyard by means of hand gear, and the mixed concrete was discharged into tip wagons running across the gantry, and delivering the concrete into the various block moulds.

At the present moment the Company are completing a mixer for concrete street work that embodies some novel features, the plant being fitted with an elevating hopper, a specially small type of engine and boiler, mounted on 3 ft. 6 in.

diameter combined road and rail wheels, so that the mixed concrete can be delivered into tip wagons, and the total overall width of the plant is only 6 ft. 4 in. This feature is, of course, of considerable value for street work, owing to the saving effected in space occupied.

Fig. 7 shows the "R-v.M" mixer, a machine recently built for contracts of short duration. It is of similar design to the Ransome, but is of a lighter construction throughout, and is a serviceable and sound machine for contractors or others who are anxious to keep their initial outlay as low as possible.

Among other specialities which are supplied in connection with the concrete mixers is the Ransome hoist, which is used for hoisting mixed concrete to the various floors of a building in course of construction, and the Gibb & Menzies' aggregate conveyors for proportioning and delivering aggregate to the mixers. This latter invention enables a larger output to be obtained from a concrete mixer than by any other known method of feeding.

The whole of the machines are manufactured by Messrs. Ransome & Rapier, Ltd., Waterside Ironworks, Ipswich, and are placed on the market by the Ransome-verMehr Machinery Co., of Caxton House, Westminster. Mixers are supplied for every class of concrete work, and the present range extends from a hand mixer with a batch of 2 cu. ft. to a power mixer with a batch of 86 cu. ft.

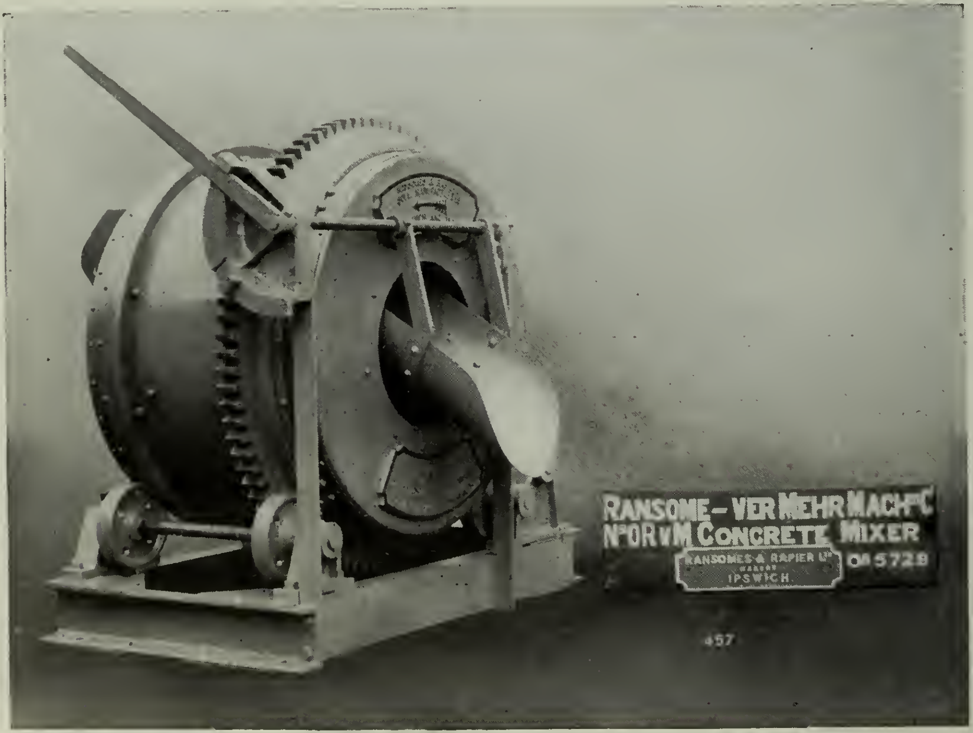
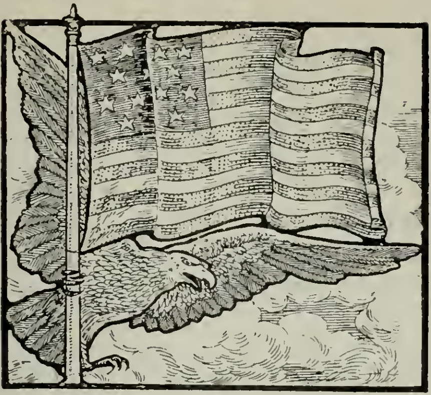


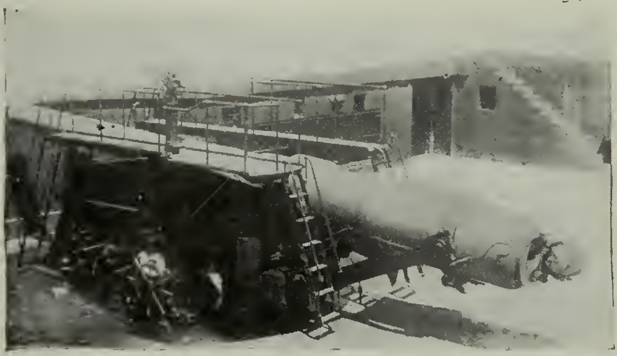
Fig. 7. "R-v.M." Mixer.



CONCRETE FOR FORTIFICATION WORK IN AMERICA.

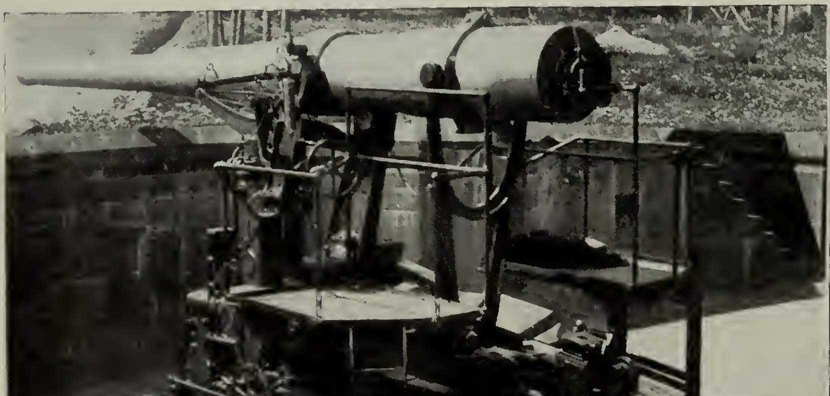
The use of concrete and reinforced concrete in military work is rapidly increasing. We would thus call attention to the multifarious uses to which concrete and reinforced concrete has been put in military works at home.—ED.

Cement was early adopted in fortification work. Now it is universally used, with steel and iron, in all such work. The parapets surrounding disappearing guns and breech-loading mortars are in every instance thickly faced with concrete, if they are not wholly constructed of the new material. The floors, ammunition rooms, runways, ramparts—everything is of cement and steel, mostly the former.

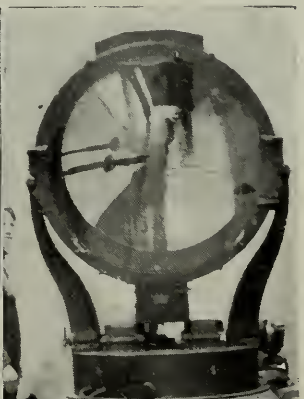


Concrete Work About a 12-in. Disappearing Rifle.

Concrete Mortar Battery.



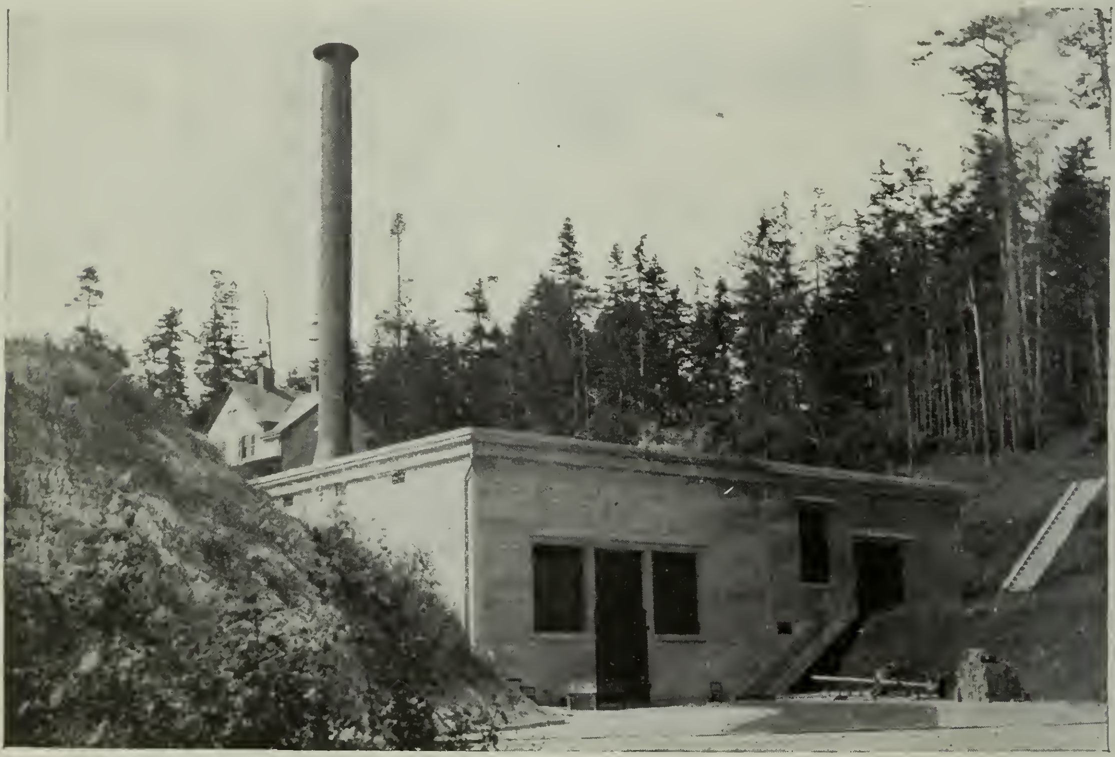
Concrete Construction Used in the Mounting of an 8-in. Disappearing Rifle.



60-in. Searchlight Sunk in a Concrete-lined Pit.

When the new American fortifications were built, and in remodelling all of the older ones, much of the work was awarded to contractors. But now the engineer corps of the U.S.A. Army, which has all construction matters pertaining to defence under its control, does most, if not all, of its own work. The execution is in the hands of commissioned officers, enlisted men and civilians. The engineers have turned out some fine, durable, and clever work in concrete construction in late years. What they cannot do with cement, sand and water is not worth recording.

All modern batteries of the coast defence are operated electrically. It is, therefore, necessary for each military post to have its own power plant. The power plant buildings, housing costly modern electrical apparatus, are invariably built of substantial concrete. To protect them from shell fire from an enemy they are located in isolated places, and are surrounded by earthworks thrown up about them to the height of the roof. One such plant-building, constructed last year, and shown herewith, is typical of this class of construction. The dynamo room rests in the side of a hill, so that the floor upon which the big dynamos stand is many feet above the boiler-room floor. The manner in which the solid concrete stairs, winding about the boiler saddles and leading on up into the dynamo room, are constructed is unique and graceful. On the outside, concrete staircases lead down the earthworks into the pit where the plant is located.



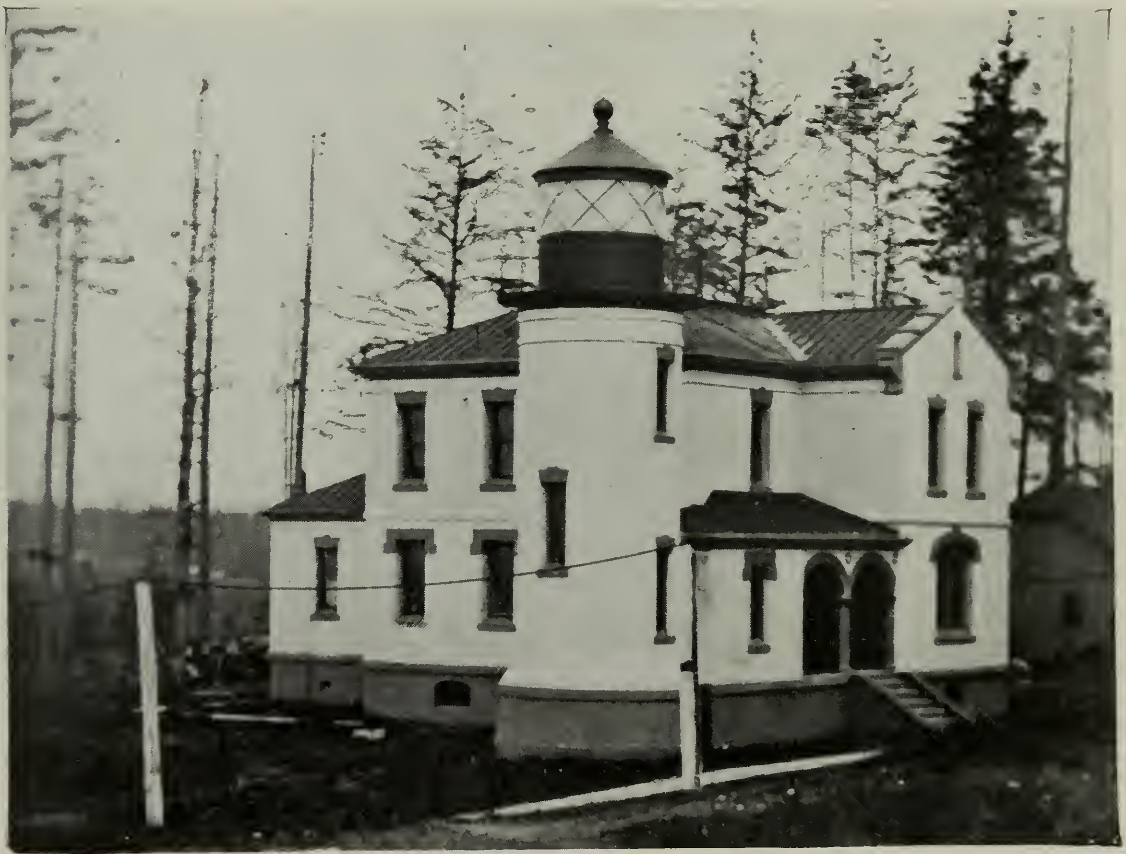
A Reinforced Concrete Coast Artillery Power Plant in U.S.A.

All American coast defence posts are now equipped with batteries of ponderous 60-in. searchlights. With them concrete plays a conspicuous part. The lights are installed in niches, concrete lined, cut high up in the perpendicular surfaces of high cliffs. At the inland end of these is a rectangular excavation in which a concrete engine house, a miniature of the large power plant, and designed to shelter the powerful gasoline motors, is built. At the bottom of the ditches tracks are laid so that the big " lanterns " may be moved back and forward on their wheeled trucks. Heavy cables connect the lamp with the motors in the engine house.

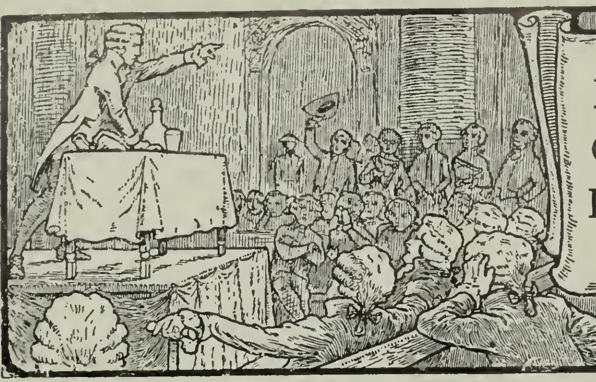
In the ammunition rooms, runways, and battery commander's stations the interior finish is elaborate. All modern batteries, as is this one, are equipped with electric lights, running water, laboratories, and toilets. Extensive sewer systems run beneath the batteries. While all guns are painted olive-green, the new war colour, the concrete work is all painted black, thus resembling, from outward appearance, painted iron.

As many, if not nearly all, of the United States coast defence garrisons are located on rocky points and promontories extending into the sea, lighthouses in the vicinity are common. These buildings, including the light towers, are also of concrete construction throughout, as shown in our illustrations.

We are indebted to the *Cement Age* for our illustrations and particulars.



Concrete Light-house Tower and Keeper's Quarters.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE ASSOCIATION OF SOMERSET SURVEYORS.

REINFORCED CONCRETE LINING TO BRIDGES.

Paper by Mr. EDWARD JOHN STEAD, A.M.Inst.C.E., Assistant County Surveyor.

The following is a summary of a Paper read by Mr. E. J. Stead before the Association of Somerset Surveyors at their meeting at Wells on May 27th :

AMONGST the duties which fall to the lot of the County Surveyor's Department is that of repairing, strengthening, and rebuilding bridges, and it occurred to the author that a description of a particular use of reinforced concrete for strengthening weak and defective structures might be of interest to the members of the Association.

Perry Bridge, Axbridge.—Last year it became necessary to deal with Perry Bridge, carrying the Bristol and Bridgwater main road over the River Yeo in the rural district of Axbridge. The structure was very defective, the stone arch being cracked and some of the masonry had fallen out. The waterway was greater than could at any time be actually required, and after some careful consideration it was decided to construct a reinforced concrete lining under the existing semi-circular arch, the span of which was 18 ft.

The thickness of the lining at the crown is 9 in., increasing to 12 in. thick at the springing level. The reinforcement consists of ½-in. diameter bars placed 1½ in. in from both extrados and intrados, these bars being transversely connected by ¼-in. square bars. An invert of beams and slab is laid between the abutments, and concrete sills are constructed at each end of the arch to prevent undermining by the river. The beams and slab forming invert are reinforced to act as tie beams, and so take up the horizontal thrust at the springing of the arch. The steel bars are so arranged as to provide continuous reinforcement all round the structure. If at any time the old masonry bridge should become so dilapidated as to require entire removal, the reinforced concrete structure has been designed of sufficient strength to entirely carry the traffic itself.

The work was carried out in the following manner. The water was arranged to flow in a chute, raised up clear of the invert work, through the centre of the archway , then excavations were taken out for sills and invert and the former were concreted in. After placing all the invert bars and connecting bars between the invert and the arch lining, the whole of the bottom was concreted up to springing level, leaving a certain length of the bars projecting upwards for connection with the arch lining bars.

The next proceeding was to fix the whole of the bars for the concrete lining, each intersection of the ½-in. bars round the arch being wired to the ¼-in. transverse bars, and the ½-in. bars were overlapped and wired on to the projecting lengths of the connection bars previously set.

The drawings showed that there must be 1½ in of concrete between the soffit of the old arch and the nearest bar, and the soffit line of the arch being very uneven and rough, it was a matter of some difficulty to ensure this. The soffit was carefully tried all over, and the points found where the stones sagged down lowest out of true curve line, then the bars were set 1½ in. below each point. Thus in places there is more than 1½ in. of concrete over the upper bars.

After all the reinforcement for the lining was securely fixed in position the centering ribs were set at their proper level—*i.e.*, 3½ in. below the lower bars, allowing 2 in. for laggings, so that the concrete would cover the bars by 1½ in. All the ribs having been braced together, the concreting of the arch was commenced. Lagging two boards wide was placed right through the bridge just above springing level and that strip of arch concreted; next a similar strip at the opposite springing, then again another strip along the first side, and so on alternately up each side of the arch until the concrete reached a height at which it was not possible to place any more in from the sides. The face boarding on the upstream side was then rigidly strutted so as to allow of concrete being rammed against it, and the lagging, section by section, in 4 ft. lengths, was laid and the arch ring completely closed. This stage of the work was very difficult, as only very small quantities of concrete could be placed and rammed at one time, and the men were working in very cramped positions. Another point noted was the trouble experienced in arranging for thorough ramming of the concrete during the closing in part of the work. The net distance between upper and lower bars was 4½ in.—too shallow to allow a satisfactory ramming tool to be worked in such a cramped situation.

At the two faces of the bridge the lining projects 6 in., and is made 15 in. thick, covering 6 in. of the old arch face.

The concrete was composed of 3 parts of Teign Valley granite chippings ¾-in. to ¼-in. gauge, 2 parts of sand, and 1 part of Portland cement. The reinforcement was indented steel bars.

The total quantity of concrete in the work was 39 cu. yd., and the weight of steel bars 1¼ tons.

The sand, obtained from the river bed at the bridge, required screening and washing before use, and a very simple and cheap manner of doing this was adopted. Beneath the outfall end of the chute carrying the water through the archway a timber platform was laid on the river bed. Over this platform a ¼-in. mesh screen was set with its outer end resting on the platform and the inner end fixed immediately under the end of the chute, from which, of course, a constant stream of clean water issued. The sand and gravel as taken from river bed was thrown into the screen and there stirred and raked until all the sand was washed through on to the platform beneath. The accumulation of gravel and *debris* was, as necessity demanded, shovelled away from the foot of the screen, and the sand was taken from the platform, washed and cleaned, and heaped up ready for use.

The cost of the whole of the work described was £88, and it occupied five weeks in construction, the contractors being Messrs. George Pollard & Co., Ltd., of Taunton.

The strengthening answers the purpose of a new bridge, which would probably have cost £500.

Newhaven Bridge.—The second work of this nature was the strengthening of Newhaven Bridge, which carries the Ilminster and Honiton main road over the River Yarty in the Chard Rural District at the county boundary with Devon. The rough stone arch was in a very bad condition indeed, so much so that the men engaged on the strengthening had on several occasions narrow escapes from injury by pieces of the arch stones falling down. The masonry abutments were good and sound. The arch had a span of 20 ft. 6 in., with a rise of 5 ft. 6 in., the springing level being 7 ft. 3 in. above the bed of the river. This waterway was greater than needed.

The strengthening, as designed, showed reinforced concrete foundations 2 ft. 3 in. wide and 1 ft. 3 in. thick, carrying abutment walls 1 ft. 3 in. thick, at the bottom battening to 1 ft. thick at the springing level, these walls being immediately in front of the existing abutments and reinforced with bars 1½ in. from the face thereof, with a second set 1½ in. from front face of the new walls. The arch lining was practically similar to that described previously for Perry Bridge.

In carrying out the work it was decided to profit by the experience gained at Perry Bridge, and the lining was constructed 12 in. thick all round, the extra depth being amply justified by the greater ease and better work possible in the concrete ramming. Modifications in the design were made in constructing the foundations. It was found unnecessary to go down to the depth anticipated, an excellent compact gravel bottom being found at the level of the foundations of the existing abutments. The bottom of the excavation was sealed with a slab of plain concrete, 3 ft. 6 in. wide and 9 in. thick, which enabled the water to be pumped out, and the reinforced concrete footing to be put in quite dry. Upon this the walls were put in up to the level of 2 ft. below springing to allow of overlapping and connecting arch bars, in order that the reinforcement might be continuous throughout and all round the lining from foundation to foundation The arch was concreted in the same way, and the materials were similar to those already described.

The total quantity of concrete used in the work was 65 cu. yd., and the weight of the steel bars $2\frac{3}{4}$ tons.

The work mentioned above cost £230 and occupied six weeks in construction, the contractors again being Messrs. Pollard & Co., Ltd.

In this instance a new bridge would probably have cost £800.

In the two cases described above the necessity for the works arose not so much from the results of heavy traffic as from decay and perishing of the arches by percolating water from the roadway, and this emphasises the advisability of protecting all new bridge work—whatever materials are used—by an impervious coating laid over the top.

It is not practicable to waterproof in that way the tops of these linings, as, of course, the concrete must be tight up to the existing arches ; but every effort should be made to ensure the exclusion of moisture from the reinforcement. To effect this an ample covering of concrete should be allowed for—not less than $1\frac{1}{2}$ in. ; the concrete materials should be proportioned to secure the maximum density, no stone larger than $\frac{3}{4}$-in. gauge being allowed ; construction, as far as possible, should take place in dry weather ; and last, but not least, proper ramming must be done.

The Design of Small Bridges and Culverts.—While writing the foregoing, it has occurred to the author that a few remarks on points in connection with the design of small bridges and culverts may prove interesting. One of the first matters to be settled when designing is the distribution of the loading, and it is important to consider at this stage the method proposed to be adopted in carrying out the work. Consider, for instance, a slab top culvert. If the span and width are so small that the whole slab can be put in one operation without a joint and the reinforcing bars are connected transversely, the load may safely be considered as distributed over a much greater width of the culvert than is the case if the concreting is done in short sections involving several joints.

In the case of separate slabs manufactured before required and simply laid side by side on the abutments, the distribution of the load must be confined to that width immediately beneath the wheels. Such slabs, therefore, need to be of much heavier construction than reinforced concrete formed *in situ*.

It is not intended in this paper to deal with the design of arches or beams and slabs, but the author cannot refrain from pointing out that such work needs special study and experience. He has heard of culvert slabs being constructed with steel reinforcement placed at the half-depth. In that position it is useless, being practically at the neutral axis, where there is neither tensile nor compressive stress. The function of reinforcement is to take up the tensile stresses which, in a simple beam or slab, occur in the lower part. Such reinforcement, therefore, should be placed near the bottom of the slab, and at least 1 in. of concrete cover allowed below it. Shearing stresses in excess of the safe shearing stress on concrete (60 lb. per sq. in.) must also be provided for by shear reinforcement, and this can generally be economically and conveniently done by bending up bars near the abutments.

The most satisfactory manner of designing arches is by the graphic method. On consideration of span, rise, appearance and loading a section can generally be assumed, and the pressure curve drawn therefor, from the position of which the requisite amount of tensile reinforcement may be calculated.

NEW WORKS IN CONCRETE

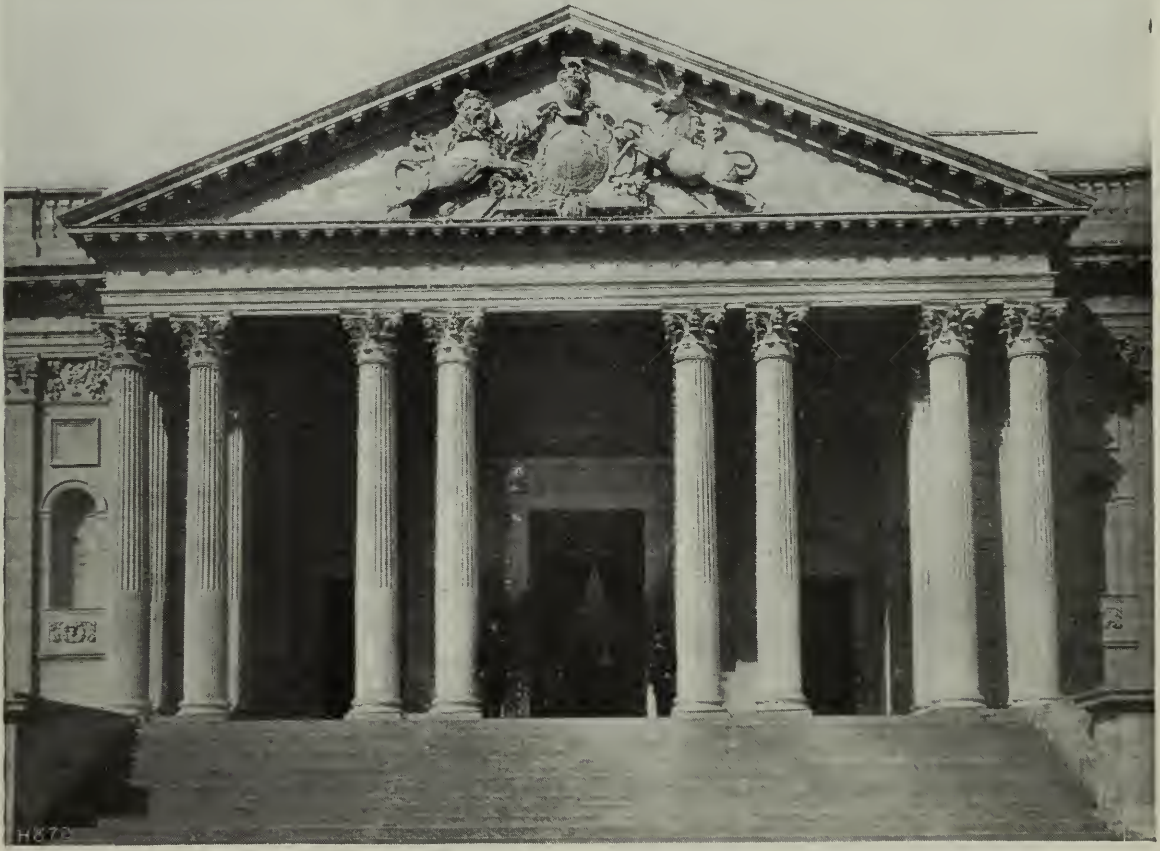
AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

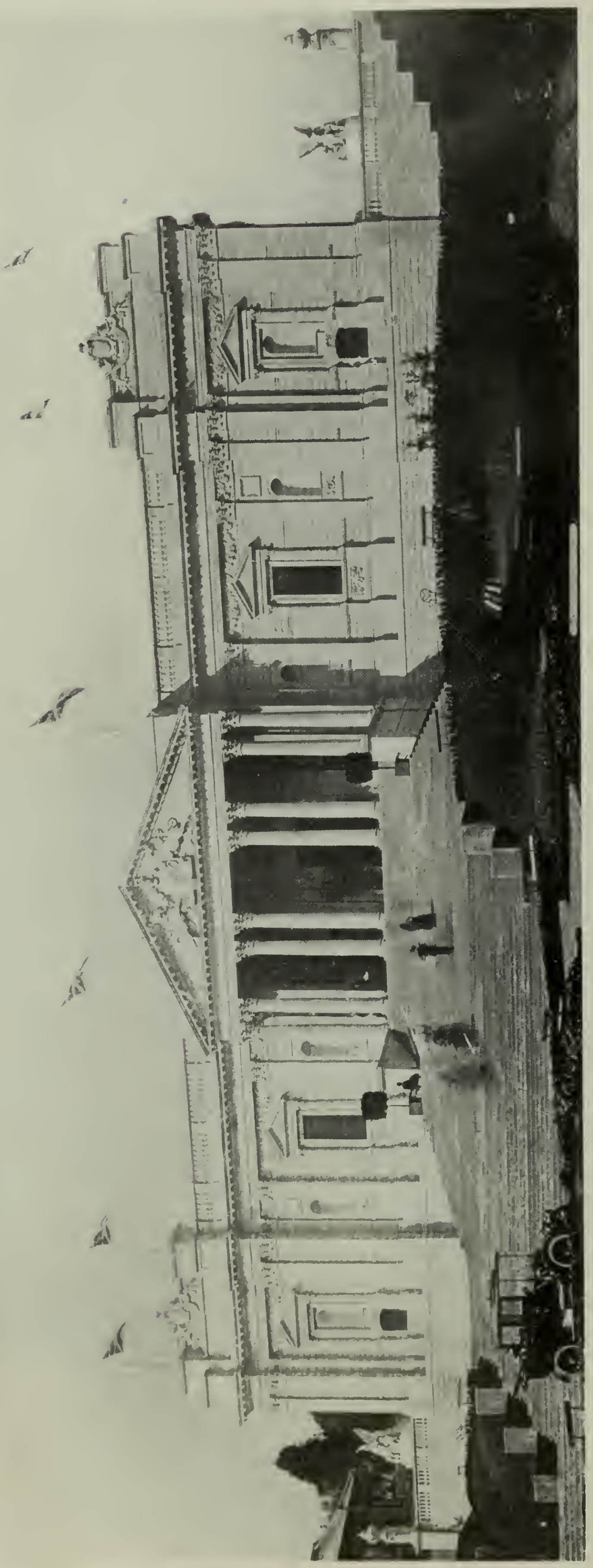
BRITISH FINE ART PALACE AT THE ROME EXHIBITION.

THE disadvantages of flimsy building construction at exhibitions were all too well demonstrated at the Brussels fire, and it is therefore very gratifying to note the plans that have been made in connection with the International Fine Arts Exhibition in Rome, and particularly at the British section, to ensure fire resistance in the exhibition buildings. It is regrettable that so little care is usually taken with such buildings, and more especially in those instances where important art treasures which are practically irreplacable form part of the exhibits.

The Rome Art Exhibition must certainly rank among the latter, and those who had the design and construction of the British section in charge certainly deserve great credit for the structure which houses the representations of our art in Rome—not only from an artistic point of view, but also for the precautions taken to ensure fire-resistance. The site occupied by the British Fine Art Palace is one of the finest in the whole enclosure, and the architect, Mr. E. L. Lutyens, F.R.I.B.A., is to be



BRITISH FINE ART PALACE, ROME EXHIBITION.



British Fine Art Palace, Rome Exhibition.

congratulated on the imposing and stately structure, which was designed by him on the model of the Upper Order in the façade of St. Paul's Cathedral.

The building is practically 180 ft. by 150 ft. The total frontage, including dwarf walls and bases, is 260 ft.

The skeleton of the building consists entirely of steel framing throughout. The main and divisional walls are all concrete 9 in. in thickness. The roof is covered with asbestos cement slates on the outside and lined on the underside with asbestos cement sheeting. The glazing throughout is of steel and lead bars. The floors are of concrete finished with floated face, and slips are bedded in this for the purpose of taking linoleum.

The main entrance steps consist of foundation walls of local rubble upon which are placed steel girders, and the steps themselves are of concrete reinforced with steel bars.

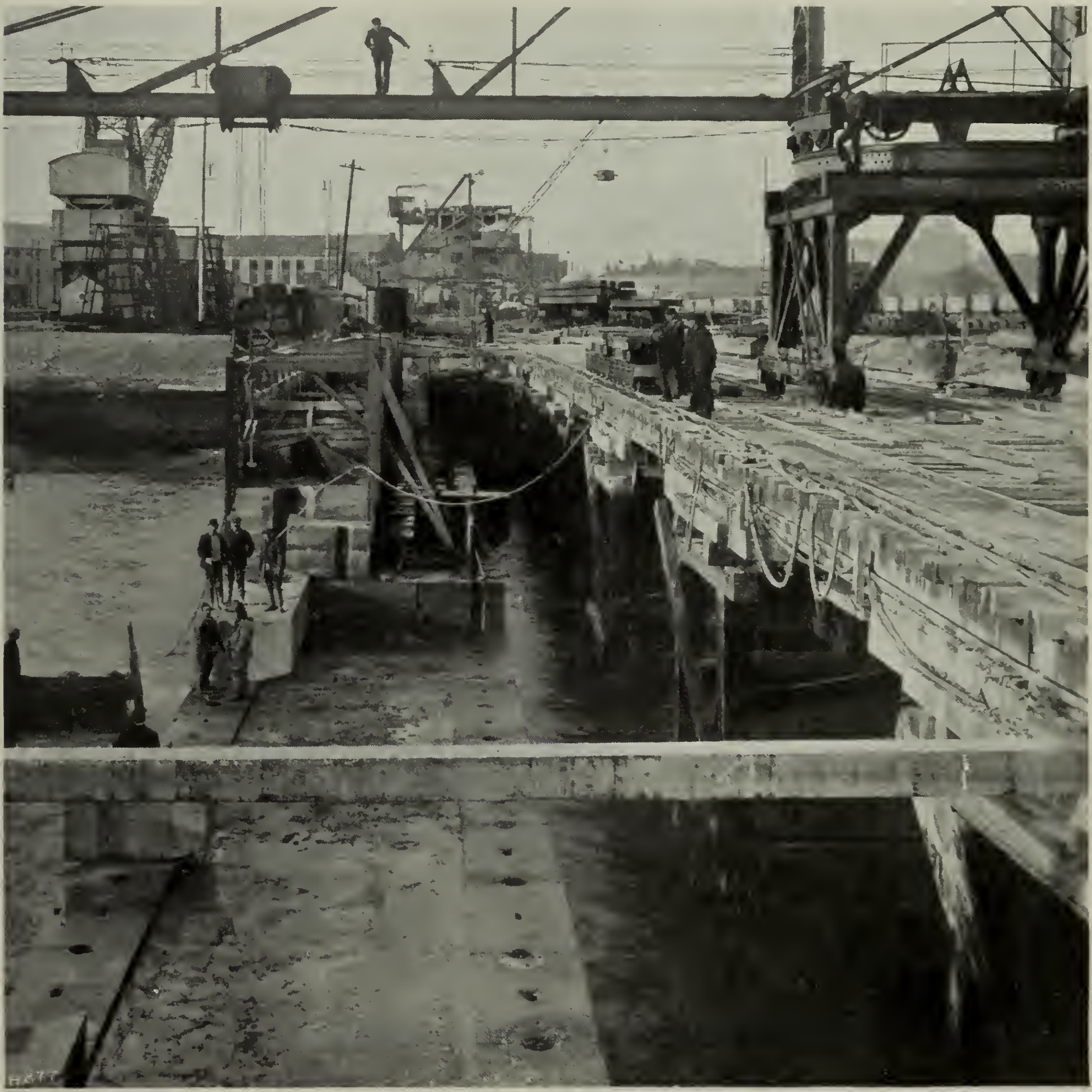
It will therefore be seen that the building is as fireproof and substantial as is possible for a structure of a temporary character. Although the British section was intended to be a temporary building, we have been informed by our correspondent in Rome that, owing to its architectural beauty, and as the construction is of so sound and lasting a character, it is the intention of the authorities to arrange that it shall be left standing permanently and be utilised for exhibition and show purposes.

A complete system of fire-extinguishing appliances has been provided.

The whole of the work in connection with this contract was carried out by Messrs. Humphreys, Ltd., of Knightsbridge.

NEW DEEP WATER DOCK AT SOUTHAMPTON.

THE new deep water dock which is being constructed at Southampton by the London & South Western Railway is now nearing completion, and is so far advanced that it was possible to berth the White Star monster vessel " Olympic " inside the dock.



Outside Quay in course of construction with 8-ton Concrete Blocks.
NEW DEEP WATER DOCK, SOUTHAMPTON.

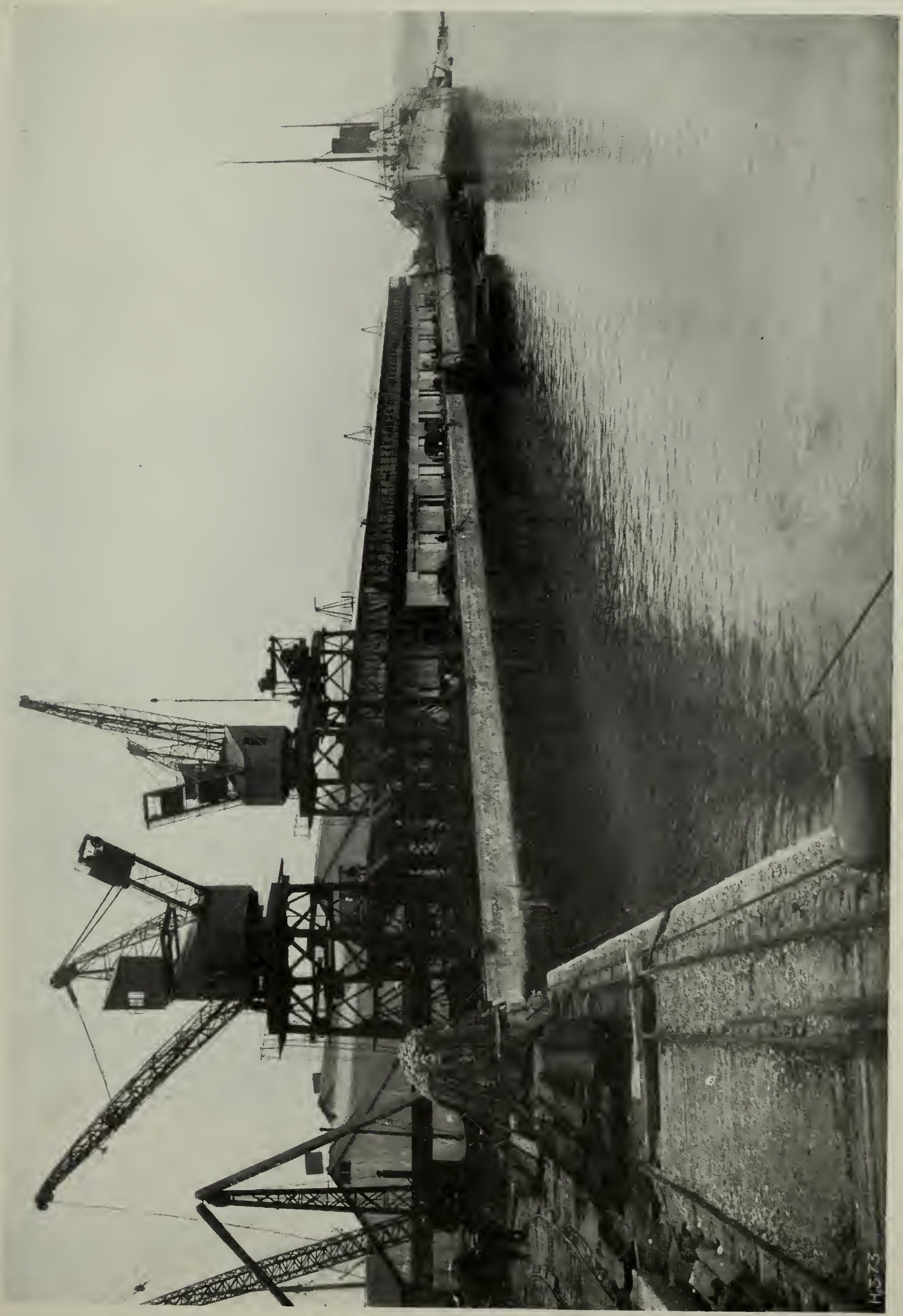
The dock itself is a parallelogram in shape, with a length of 1,700 ft. and a width of 400 ft. It will have a depth at low water ordinary spring tides of 40 ft., and at high water the depth will be 13 ft. more than this. There is no entrance lock, but it will be seen from the figures given that the largest vessel will be able to lie afloat here at any state of tide without risk of touching bottom. The dock is large enough to hold five vessels—two vessels of the largest type can berth on each side of the dock, and a short vessel against the small end berth.

The dock is surrounded with quay walls constructed entirely of Portland cement concrete. The quays are being equipped with four large steel cargo sheds. The shed which is completed has a length of 640 ft. and a width of 120 ft., with an annexe 60 ft. by 60 ft. containing stores for baggage and dock gear. The framework of the shed is of steel, the sides being covered with corrugated sheeting, and the roof with planking protected by Graves's felt. The steelwork has been erected by Messrs. Heenan & Froude, Ltd., of Manchester. The foundation consists of concrete piles driven on the "Simplex" system, and the flooring is of timber. Besides the stores in the annexe, a set of waiting rooms and lavatories is provided at the southern end, with cages for bonded cargo, and offices for the medical officer, foremen, and clerks. Along the front of the shed is a high level balcony on to which the passengers will pass direct from the vessel, and which communicates with the floor of the shed by means of two wide staircases. The shed itself is built in two spans of 60 ft., the central columns being spaced 20 ft. apart. The quay space between the ship and the shed has a width of 35 ft. This is covered with timber decking, and has two lines of rails for trucks as well as a line of rails for the large electric cranes which will deal with the cargo. Four of these cranes are being provided for the berth, two of which are capable of lifting 35 cwt., and the other two of lifting 5 tons. There will also be provided two moving bridges or stages across which the passengers will walk from the ship's side to the balcony on the shed. All the rails are connected up to the elaborate system of sidings which now exist on the docks.

Besides the dock itself, four outside quays are being constructed of lengths varying from 330 ft. to 610 ft., and with depths at low water of 25 to 32 ft.

The contract for the construction of the dock was let to Messrs. Topham, Jones & Railton, Ltd., in October, 1907. Before the works were commenced the site of the dock consisted for the most part of a bare mudland facing on the River Test. The river was shut out by means of a chalk bank, but as this was not absolutely watertight the high tide found its way through it daily and flooded the whole dock side. The first operation was to make the bank tight and strong by driving a sheeting of timber piles along its toe and covering its slope with stone pitching grouted with cement. When this was done excavation down to a depth of 30 ft. below quay level was carried out by means of steam navvies, which removed about 5,000 cu. yds. per day. To facilitate sending the material to sea, an enormous stage, 375 ft. long and 40 ft. high, was built out over the River Test. This stage formed the summit of a long incline which led right up from the heart of the dock where the steam navvies were at work filling wagons. As soon as the steam navvies had dug away the earth to the 30 ft. depth, timbered trenches were sunk down in which the foundations of the quay walls were laid. These trenches were about 43 ft. wide and 45 ft. deep. The depth to the bottom of the trench from quay level was about 75 ft. Inside these trenches the massive concrete walls were built of Portland cement concrete mixed by special machinery. The concrete was made with gravel obtained from Langston Harbour, the Portland cement from the Thames district. The large mixing machines which served this portion of the work were capable of turning out about 1,000 cu. yds. per day. Considerable difficulties were encountered in sinking these trenches, owing to underground water finding its way into the excavations, and various devices had to be resorted to in order to overcome these difficulties. Piece by piece, however, the foundation level was successfully reached and the concrete wall built up inside the trenches, and then upwards until quay level was reached. Dry material from the excavation was then placed behind the wall, and on the quay space thus formed the sheds were built and the roads were laid. Some portion of the wall at the outer end of the dock, and one of the outside quays were built in the same way as here described, except that the timbered trenches were sunk from the quay level, the open excavation being omitted. The trenches in this case were in some places 45 ft. wide and 75 ft. deep, and were remarkably fine examples of heavy timbering. As soon as the walls had been built up in this fashion the enclosing bank at the entrance to the dock was cut through, and water was allowed to enter.

Two of the outside walls and part of the western entrance wall were, however, built in quite a different fashion. Here no attempt was made to dry the site, but



View of Berth ready to receive the S.S. "Olympic."
New Deep Water Dock, Southampton.

the whole wall was built in water. To accomplish this the earth was first removed down to dredging level throughout the whole length of the wall, by means of a bucket ladder dredger. Below this level the foundations were built in a trench between two rows of sheet piling driven along the front and back of the wall. The clay between the two rows of sheeting was excavated by means of steam grabs, and cleaned up by helmet divers. On the foundation thus formed was laid mass concrete, which was lowered through the water in special tipping boxes. Above dredging level the wall consists of large 8-ton concrete blocks at face and back, with a hearting of mass concrete. This style of work is continued up to above low water level, after which the wall is constructed wholly of mass concrete laid between shutters in the usual way. When the wall has reached quay level it is backed up with ashes or special selected material. Although the works are still incomplete, the following quantities have been dealt with :

873,000 cu. yds. of open excavation.
318,000 cu. yds. of tench excavation.
807,000 cu. yds. of dredging.
272,000 cu. yds. of concrete laid.
42,000 tons of Portland cement used.

The designs for and the supervision of these works have all been in the hands of the London & South Western Railway Company's Docks Department, of which Mr. T. M. Williams is the manager. Mr. W. R. Galbraith, a former vice-president of the Institution of Civil Engineers, who has been associated with all the large extensions at Southampton since 1892, has acted as consulting engineer, and Mr. F. E. Wentworth-Shields, M.Inst.C.E., has been the resident engineer.

Reinforced Concrete Bridge, Whiston Street, Shoreditch.

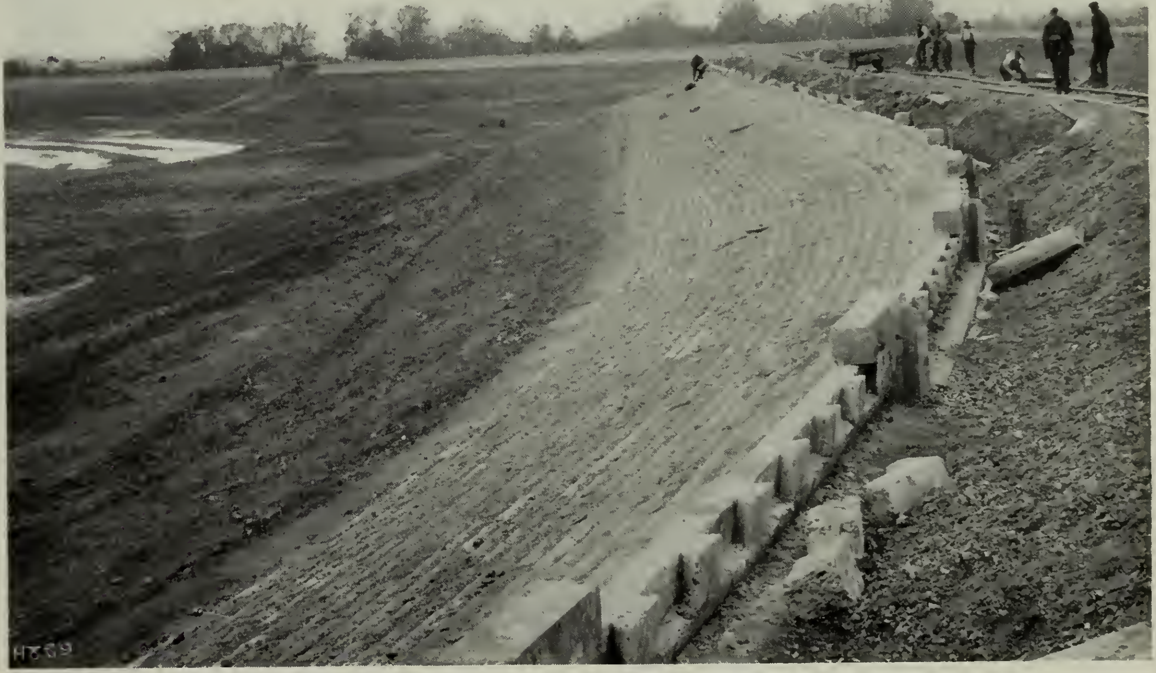
REINFORCED CONCRETE BRIDGE, WHISTON STREET, SHOREDITCH.

This reinforced concrete bridge replaces an old cast-iron structure which had been condemned as unsafe. It spans a branch of the Regent's Canal, about 24 ft. 6 in. wide between the existing brick abutments. The bridge has a total width of 32 ft. between parapets, which are also entirely in reinforced concrete. Constructionally it consists of six main straight girders and two parapet girders, carrying a $5\frac{1}{2}$ in. decking with special provision for pipes, etc., under the footpaths. There are in fact under one footpath three 24-in. gas mains, and under the other twenty main electricity feeder cables and thirty-two troughs for future use.

The roadway is formed of wood blocks, giving a covering over the reinforced concrete of merely 6 in.

The bridge was tested on April 13th, 1911, in the presence of a large number of the councillors of the borough of Shoreditch. A steam-roller loaded with pig-lead was run on to the centre of the bridge, when the maximum deflection recorded (several instruments were used) was one-sixtieth of an inch. The allowable deflection was one-six-hundredth of the span. Afterwards the roller was run backwards and forwards over the bridge when a remarkable absence of vibration was noticed.

It is interesting to note that this bridge is the first reinforced concrete highway bridge to be erected in the London area. It was designed by Mr. T. L. Hustler, borough engineer of Shoreditch, with the collaboration of Messrs. Mouchel & Partners, of Westminster.



Showing Method of Keying in Blocks to Concrete Backing to Vertical Wall.
Island Barn Reservoir.

CONSTRUCTION OF THE ISLAND BARN RESERVOIR.

The reservoir now approaching completion at Island Barn, for the Metropolitan Water Board, has an area of 120 acres and will contain about a thousand million gallons of water. The periphery measured on the top of the embankment is 1¾ miles. It is situated at East Molesey, in Surrey, and will be used for the Southern district and the Chelsea division of the Western district.

The intake conduit from the Thames is an open channel, 480 yds. long by 22 ft. wide, with a normal depth of 8 ft. The engine and pump-house is built over the conduit, from which the water is lifted by four double stage centrifugal pumps, each of which is driven direct by a 500 h.p. vertical triple-expansion engine.

The new delivery pipe is 2,900 yds. long and was laid in a trench which varies in depth from 9 ft. to 16 ft., the whole work of digging the trench and laying the pipe occupying six months. Before the work was put in hand a large number of trial borings were made. It was found that there was London clay throughout at a depth of from 16 ft. to 32 ft., above this being sand and ballast, with overlying clay in some places. The latter provided all the aggregate required for concrete.

The earthwork at the outer side of the embankment is at a slope of 2½ to 1. On the inner side the lower part has a batten of 4 to 1 and the upper 3 to 1, the latter, to prevent damage from wash by the water, being paved with concrete slabs, and near the surface of the water with rock-faced concrete blocks, set in ballast, with a wall faced with similar blocks at the top, completed with a concrete coping. These were made in iron moulds supplied by the Winget Concrete Machine Co., Ltd.

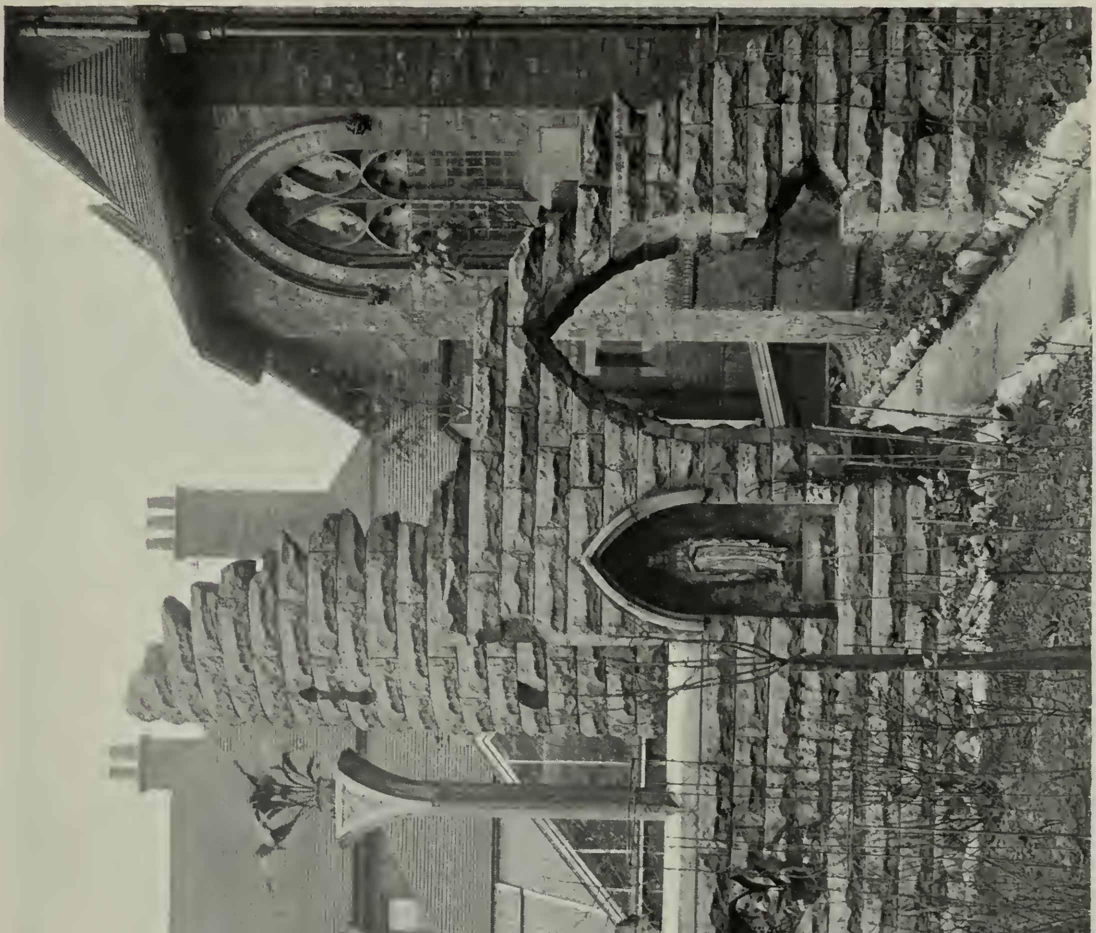
At the inlet the whole of the embankment on both sides of the puddle wall is of concrete. The pipes run up the outer side at an inclination of 2½ to 1 and discharge into a basin with a granite sill, the water then flowing down a flight of steps of blue brick with concrete nosings. This flight of steps, which is 30 ft. wide, is carried down to the bottom of the reservoir and terminates in a concrete apron, 60 ft. by 30 ft. and 12 in. thick.

In constructing the outlet two shafts were sunk, 10 ft. internal diameter and 72 ft. apart, 36 ft. on either side of the puddled wall. They are lined with concrete 4 ft. thick. These shafts are carried to a depth of 39 ft. 7 in. below the concrete, which forms the toe of the inner slope, and 78 ft. below the top of the embankment. A pipe 36 in. in diameter passes through the wall of the inner shaft near the bottom of the reservoir with two valves, one on the outside and one on the inside, worked from the platform at the top of the shaft. In the outer shaft similar valves allow the water to pass out through pipes 36 in. diameter, which connect to the existing mains by 54-in. and 36-in. diameter pipes respectively, bedded in concrete.

Showing Completed Lining of Concrete Blocks and Coping.
Island Barn Reservoir.

The two shafts are connected by a circular tunnel. In constructing this tunnel, concrete segments 4-in. thick were made in moulds, and every block is grooved or tongued on all four sides, so that eight sections form a ring 12 in. wide. Directly a length was excavated the segments were placed in position, jointed in cement mortar and grouted outside under pressure, similar to cast-iron tunnels. The concrete has stood for a year with only the 4-in. concrete segments for lining and has been found to be perfectly satisfactory.

The reservoir was designed by W. B. Bryan, M.Inst.C.E., Chief Engineer of the Metropolitan Water Board. The resident engineer is Mr. A. P. Maddocks, M.Inst.C.E., The pumping station, machinery and intake works were designed by Mr. J. W. Restler, M.Inst.C.E., Deputy Chief Engineer of the Board.



CONCRETE BLOCKS AT ST. PETER'S CHURCH, SOUTH BANK, TO REPRESENT OLD CHURCH RUINS.

CONCRETE BLOCKS TO REPRESENT OLD CHURCH RUINS.

THE accompanying illustration shows work done by concrete blocks at St. Peter's Church, South Bank, Norton-on-Tees, to represent old church ruins. The blocks were made with the "Dring" block machine, supplied by the Stockton Stone and Concrete Co., Ltd.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

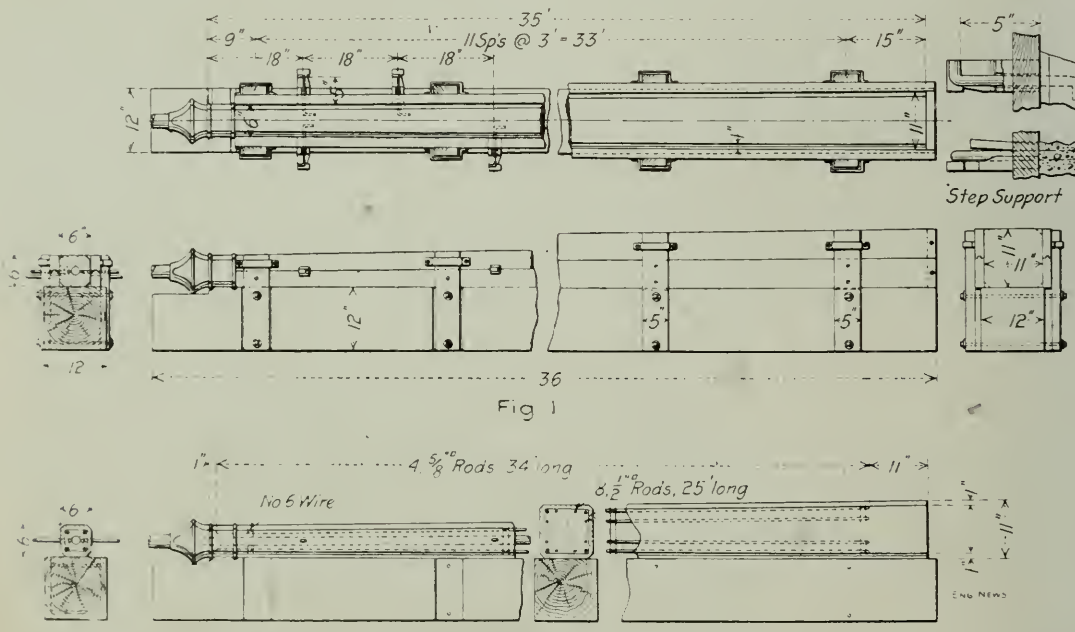
Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork, where structures of great height are required.—ED.

REINFORCED CONCRETE ELECTRIC LAMP POLES, ST. MARY'S FALLS CANAL, MICHIGAN.

The Improvements in Progress.

THESE reinforced concrete lamp poles were required to replace the old timber poles previously in use, which had constantly to be renewed because of decay. Before deciding to make use of reinforced concrete for the new poles it was agreed upon to build an experimental pole of concrete to test the adaptability of the material and determine the cost, and this experiment proved so satisfactory as to warrant the construction of 40 poles of the same general type.

The poles are 11 in. square at the base and 6 in. at the top. The reinforcement consists of one $\frac{5}{8}$-in. square twisted bar, 34 ft. long, in each corner, extending from about a foot above the base to the top, and two similar bars, $\frac{1}{2}$ in. square, 25 ft. long, in each side, extending to within 9 ft. of the top, so that the cross-sectional area of the reinforcement for the bottom part of the pole is 3·56 sq. in., but for the top 9 ft. of the pole it is only 1·56 sq. in. The bars were tied together at intervals of 4 ft., with two turns of No. 6 soft steel wire, bent to a square, within which the rods were placed and secured at proper spacing by winding with stone wire, as shown in *Fig.* 2.



Forms and Reinforcement for Reinforced Concrete Lamp Poles, St. Mary's Falls Canal.

The wires are brought from the main conduits through 2-in. galvanised duct to the concrete base, in which the pole is set, and up along the outside of the pole to the cut-out box, located about a foot above the base.

The poles were moulded in a horizontal position, and the forms for the concrete are shown in *Fig.* 1.

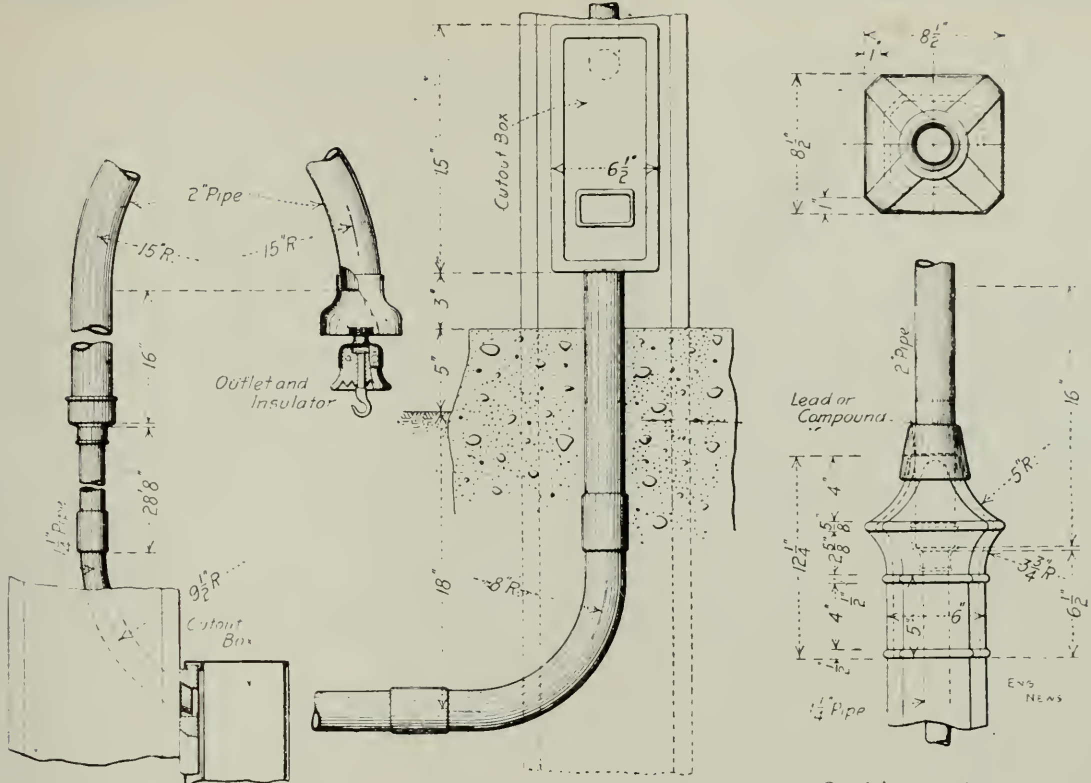
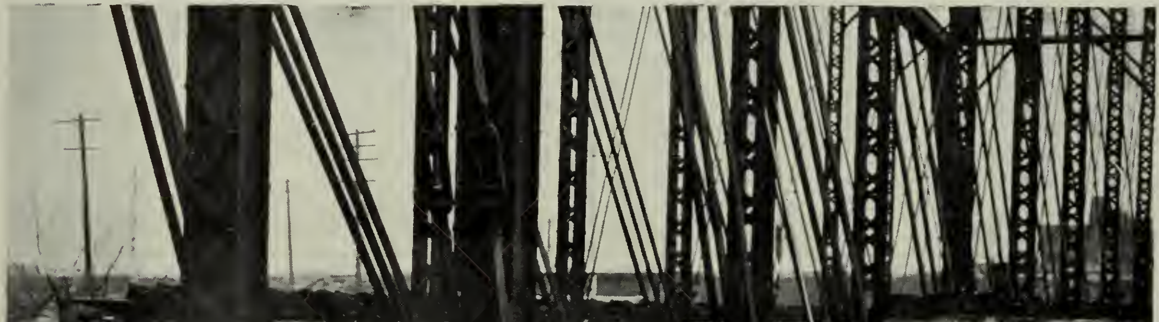


Fig 3　Fig 4　Cast iron cap.

Pole and Base Crooks for Reinforced Concrete Electric Lamp Support.



Testing a Reinforced Concrete Electric Lamp Support, St. Mary's Falls Canal.

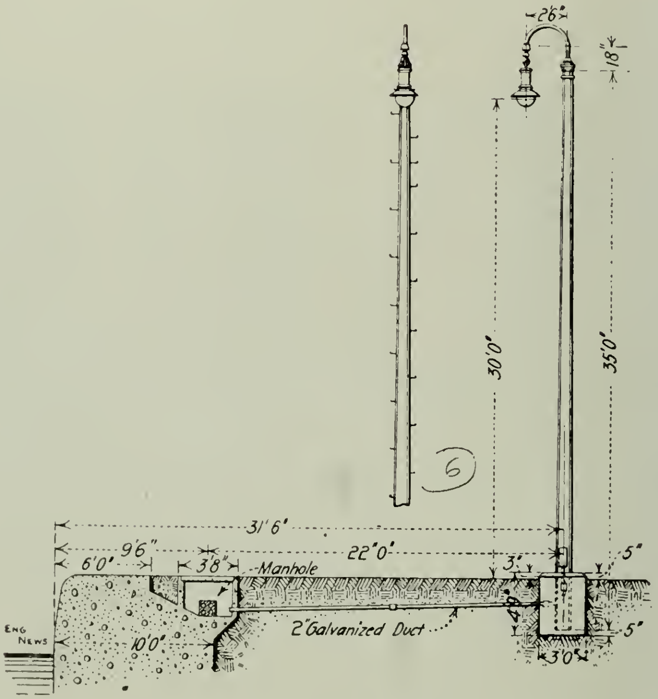
The rods for reinforcement having been purchased in the lengths needed, the first step in assembling them was to bend the wire ties or bands to the proper sizes to fit around the rods at intervals of 4 ft., and keep the rods to the taper which the shape of the pole required. These wire bands were placed in the form around the rods, and each rod was tied with wire to each band at the point of crossing. This resulted in a unit of reinforcement that was quite rigid. The central pipe was then placed and secured, the steps adjusted with their wedges, and the top casting placed over the upper ends of the reinforcing rods ready to receive the concrete.

The concrete used was mixed in the proportion of $1\frac{1}{8}$ barrels cement, 7 cu. ft. of sand, and 14 cu. ft. of limestone screenings. This batch made about 15 cu. ft. of concrete, or sufficient for one pole.

As a general rule, these poles are set $31\frac{1}{2}$ ft. back from the face of the canal wall, in a block of mass concrete 3 ft. square by about 4 ft. deep.

The work was carried out under the supervision of Mr. L. C. Sabin, M.Am.Soc.C.E., general superintendent, St. Mary's Falls Canal, Michigan. The drawings illustrating this article were very kindly placed at our disposal by our contemporary, *Engineering News.*

Reinforced Concrete Pole in place, St. Mary's Falls Canal.



Reinforced Concrete Arc-Lamp Pole at St. Mary's Falls Canal.

CORRESPONDENCE.

Under this heading we invite correspondence.

92 Tooley Street, London Bridge, S.E.

Ready Reckoners for Reinforced Concrete Work.

Dear Sir,—I have very carefully perused the review of my publication, entitled *Ready Reckoners for Reinforced Concrete Designs*, which appears in your June number.

Your reviewer is, of course, entitled to his own opinions, and that is all very well as long as he points out substantial and real errors and defects. In saying "the calculators are of doubtful utility," and, again, "instead of their substantiating the author's intention that they should reduce risks of error in calculations we fear that they might be more likely to increase it," he goes, however, too far, as the logical conclusion from these sentences is that the reckoners give false results.

Now, I contend that this is *not* the case, and, as his statements, apart from affecting the sale of the publication, must naturally affect my professional reputation as a writer and designer in ferro-concrete, I am not content to let the matter rest there.

If your reviewer can show me a single instance in which the reckoners do not give precisely the same result as the formulæ generally used, I am satisfied to bow to his superior judgment and wisdom. If, however, he cannot do so, I shall have to call upon him to withdraw his remarks, which I contend are quite erroneous and an unfair criticism.

As to the technical points of the case, it is clear that all calculations in ferro-concrete must necessarily be based on certain assumptions ; it is clear that a certain width of the table of a "T" beam must be assumed to make any calculation at all ; it is clear also that there can be only one depth of a beam in which the materials are stressed to best advantage and economy. These bases have been adopted, and the most tedious calculation could not possibly give another result. The reckoners are not arrived at graphically, but each figure is obtained from actual calculation by means of formulæ involving some six months of very tedious work to the author.

I am constantly using these reckoners, particularly for floor designs, and many thousands of yards of floors have been executed, the designs of which were purely and simply based on these reckoners. Most of these floors have been subjected to exhaustive tests, with the very best results, and not a single failure has occurred.

I may further point out that some of the leading specialists of the day in this country as well as abroad use my reckoners, have tested them, found them absolutely correct, and have congratulated me on such correctness, and expressed their pleasure to use them, as they save such a lot of time and prevent mistakes.

In face of these facts, you will agree that it would be unfair to me to have an important publication like this simply pronounced wrong without its being proved in any way that it is so, and I must call upon your reviewer to substantiate one single instance in which he obtains a different result from the reckoners from that which he obtains by means of the usual formulæ. F. Rings.

The Editor, Concrete and Constructional Engineering.

Our Reviewer's Reply to the Above.

In answer to the above I will single out a few points from the work in question, and illustrate my remarks by an example :

Supposing I require a T-beam to carry an inclusive distributed load of 4,600 lb. per ft. run, with a span of 48 ft. freely supported. Now, using Mr. Rings's diagram No. 4 (for limiting stresses of 17,000 lb. per sq. in. in the steel and 600 lb. per sq. in. in the concrete), this shows the effective depth to be 30 in. and the area of steel 35·2 sq. in., taking the breadth of the table of the "T" as 16 ft., for which assumption he stipulates.

Checking by the formulæ in the R.I.B.A. Committee's Report we find, with this sized beam and area of steel, that if the thickness of the table or slab be 10 in. then the stresses are 17,000 lb. per sq. in. in the steel and 600 lb. per sq. in. in the concrete, but if the slab be 3 in. the stresses are 15,800 lb. per sq. in. in the steel and 1,076 lb. per sq. in. in the concrete. The latter, to say the least, is a considerable difference from 600 lb. per sq. in., though Mr. Rings may not call it an error. Again, it is conservative practice to take the width of table at not more than fifteen times the thickness, which, if 10 in., would give 12 ft. 6 in. and if 3 in. would give 3 ft. 9 in.

Another limit usually imposed is that the width shall not be greater than three-quarters the spacing of beams. Mr. Rings says nothing of this. His "one-third the span" might easily exceed the distance between beams.

I may note also that in speaking of slabs sometimes requiring compressive reinforcement he says: "These compression rods are usually arranged so as to run in opposite directions to the tension rods." I may be misinterpreting his words, but this seems to me to advise putting compression rods at right angles to the tension bars, in which position they would not be of much avail in resisting the compression.

I think it likewise inadvisable for him to state that the width of rib must be left to the judgment of the designer, and that two or more rods should be bent up towards supports to resist shear and reverse bending moments. They are quite general statements, I know, but I contend that they might lead the inexperienced designer into errors of omission.

Neither do I agree that it is sufficient to advise that central bending moments in continuous slabs be taken as $\frac{Wl}{14}$. I put it mildly when I said that that is not always correct.

I hope that this will satisfy Mr. Rings without my going further in the matter.

REVIEWER, C. AND C.E.

June 20th, 1911.

Retrogression v. Progress in Building Construction.

DEAR SIR,—I should be glad if you could find space in your columns for the following remarks:

With a view to the reduction in cost of elementary schools a committee was last year appointed by the Education Department to consider the use of "novel" materials and methods of construction, with due regard to "durability and suitability." As the practical result of their deliberations a school for 300 children has just been erected at Old Harley, Northumberland, to take the place of a building recently destroyed by fire.

The new building, as described in the pages of a technical journal, is a "timber-framed building" encased with slabs, composed, I understand, of plaster and straw. These slabs are secured to the framing both externally and internally, those on the outside being rendered in cement, etc. In the event of an outbreak of fire (a risk, under the circumstances, which could hardly have been overlooked), the moment the flames break through the roof and window openings the wood framing would be immediately attacked and promptly demolished.

Deprived of proper ventilation, the occasional air gratings being totally inadequate, the framing is doomed to decay, and, as it is subjected to a high temperature on the inside and a colder temperature, accompanied by more or less dampness, on the outside, the necessary shrinkage and expansion of the timbers must lead to the cracking of the plaster slabs and their ultimate destruction by wet and frost.

Were this a private experiment I would not bring it to your notice, but, being the act of a Government Department using public funds, it appears to call for stringent criticism. It would be interesting to know what steps were taken by the committee to discover materials suitable for their purpose.

It seems to me that, in view of the conditions laid down for their own guidance, the material selected should have possessed the following essentials—viz.:

(*a*) Composed of ingredients that would withstand the action of the weather.

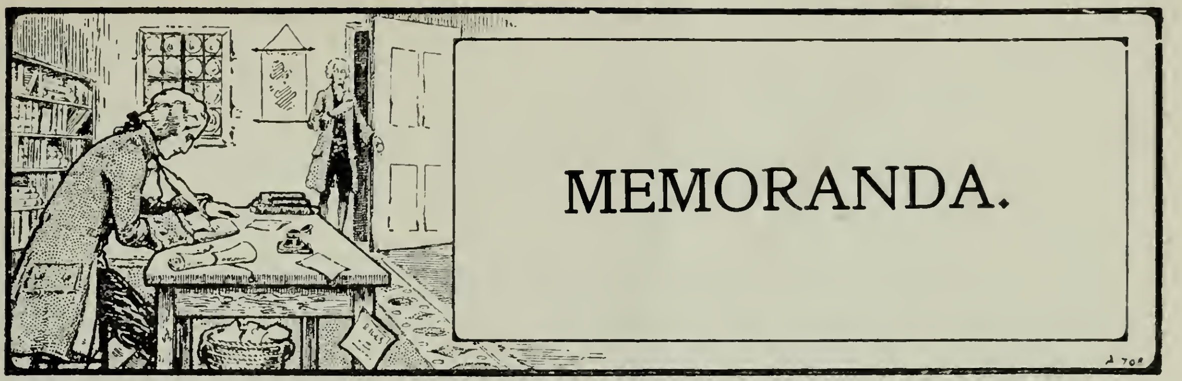
(*b*) Fire-resisting in a high degree.

(*c*) Capable of standing on its own merits, without trusting for support to wood framing.

Materials possessing these qualities have been on the market for over ten years and can thus hardly be deemed "novel," and have been used by H.M. Office of Works. It therefore seems unfortunate, both in the interests of the public and of building advancement generally, that the Education Department should have placed their seal of approval on a method of construction which is generally condemned and practically obsolete, and have been content to obtain a building which cannot be better described than a glorified lath and plaster erection at a considerably higher cost than they could have erected out of materials that would have satisfied their own original conditions.

Yours faithfully,

The Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING. C. A.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Waterproofing and Colouring Compounds.—The colouring of concrete, which has been a very perplexing problem, is gradually becoming simplified and certain. The demand for artistic and satisfactory exterior colour treatment has now become very general. Experimenters in the concrete colouring fields have groped and tested for years with but few successes. Many methods of colouring have been tried from time to time, but certain of these have been proved to weaken the bond, and engineers and architects are agreed that even the slightest weakening is most undesirable. Another method which has been employed and which has been found quite satisfactory, where colour only is desired, is that of the special coatings, compounds that avoid the weakness of paint, but which are essentially painty in their character and form a thick coating over the surfaces of the cement. But for those who desire to preserve the natural texture, and at the same time to get an artistic colouring effect, such a material will not be satisfactory. Therefore, it is for the large and increasing group of cement users who desire something that will cover the surface of the concrete without giving it with a thick coating like paint that the transparent cement stains have been designed. They sink into the pores and preserve the natural texture of the cement.

Among the many advantages claimed for stains is the ease and rapidity with which they can be applied. Then they are more economical in that they cover from twice to three times as much surface per gallon as the heavy paints, and the wearing qualities are far more satisfactory. The fact that they do not form any skin or coating over the surface makes it impossible for them to crack or peel off.

But, in addition to these colouring advantages, the stains waterproof the surface completely and permanently. The vehicle contains an indestructible waterproof compound, which enters and seals the pores of the concrete, and as it does not oxidise by age, this waterproof effect lasts for all time.

It would seem, therefore, that the opening remark about the solution of the colouring problem for concrete is amply justified, and the pathway of good colouring should be clear for the future.—*Cement Age.*

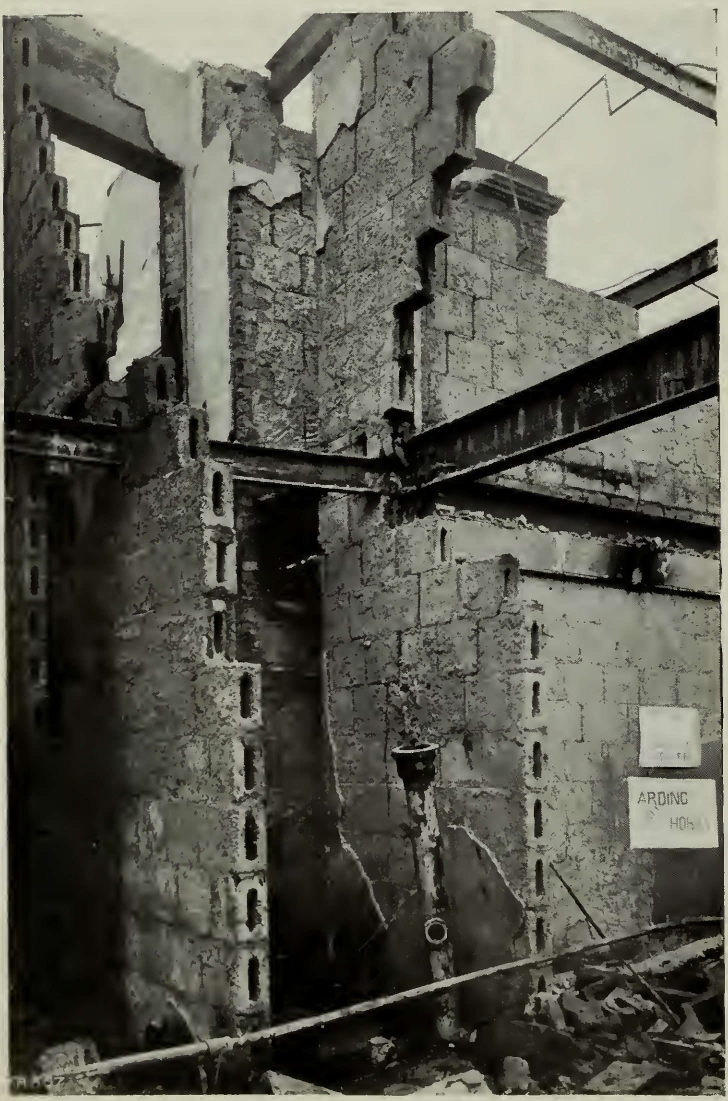
Experience with Cement Mains at Rahway, New Jersey.—In the volume of the 1910 Proceedings of the American Water Works Association, Mr. Wm. Bishop describes about 12·6 miles of cement mains, which were laid in Rahway, New Jersey, in 1871, the largest of these being 12 in.

Each section of pipe is 7 ft. long and consists of a sheet iron shell rivetted lengthwise, and lined both inside and outside with a coating of cement ½ in. in thickness. The larger sizes of pipe are butt-jointed with a short band at the joint. The smaller sizes are made with one end 1 in. larger in diameter than the other, and the small end of one pipe is laid inside the large end of the next, about 4 in. About 18 in. from the large end of the pipe a spud is placed with a lock nut on each side of the sheet iron shell ; this spud is imbedded in the cement coatings sufficiently to cover the lock-nuts, and is filled with cement also ; a wooden block is put over it for its protection. To make a tap it is only necessary to uncover the spud, drill out the cement, and attach the connection. The usual pressure under which we operate is 40 to 45 lbs. at the works, and as the city is comparatively level, the pressure is nearly the same throughout. The pipe can be made to stand any moderate pressure by the use of a shell of proper thickness. In this particular pipe the shell does not appear to have been coated before being lined.

The 12-in. mains have needed scarcely any repairs, and experience has shown that where the pipe is properly laid on good, firm ground, with the pressure used here, there is very little trouble ; where the ground is made or marshy, the pipes are more apt to settle, and if the outside cement coating cracks, the air and moisture rust the sheet iron shell and eventually it breaks.

When we have had to cut into the pipes, for any cause, we have found them absolutely without incrustation or deposit, and uniformly clean. The shell itself, with the exception of where the outside coating of cement was cracked, was as bright as it was when laid thirty-eight years ago.

Had cast iron pipe been originally laid, we would now be experiencing more or less trouble for want of proper pipe capacity, while to-day, although they were guaranteed for only twenty years, there is no reason to believe there is any general deterioration in the mains. Our water is considered an excellent one for boiler use.



View of Portion of Concrete Partition after the Clapham Junction Fire.

Concrete Partition Slabs.—The value of partition slabs of concrete for fire resistance is very plainly shown by the accompanying illustration, made from a photograph which was taken after the disastrous fire at Messrs. Arding & Hobbs' premises at Clapham Junction. This partition consisted of $4\frac{1}{4}$ in. hollow concrete blocks, the larger portion of them being left perfectly intact as shown, whereas all the wood framing and most of the plaster was destroyed. Owing to the severe impact by the falling debris, some of the blocks fell to the ground, but they remained practically unchanged by the fire.

The blocks in question were supplied by Messrs. J. Wright & Co., of New Malden, Surrey, and are made of the best English Portland cement, thus ensuring their resistance to fire.

These blocks are easily cut, their erection is a very simple matter, and they are also perfectly rigid without the use of irons. The blocks can be finished externally with cement rendering, to provide a thoroughly weatherproof building. They can also be used for either air or smoke flues. These blocks are specially useful where temporary buildings are required, as they fulfil the requirements of low price necessary for such work, giving at the same time a permanent structure.

Wright's partition blocks have lately been used in the erection of many large Government and industrial buildings.

Concrete Boats in California.—A concrete barge and pile construction plant, involving an outlay of $150,000, has been established on the Oakland estuary, San Francisco. The barges will be used for handling freight between San Francisco and Sacramento. Tentative orders for thirteen barges have already been received. A boat now in course of construction will be 100 ft. long by 30 ft. wide, and will receive its buoyancy from 26,160 cu. ft. of "locked" air. The base will be shaped like the ordinary wooden barge and will be 7 ft. deep. Through this base concrete walls will be built for the entire length of the structure every 6 ft. Similar walls will run for the width every 6 ft. apart, forming air chambers 6 ft. sq. There will be eighty of these, making it impossible for the barge to sink, no matter how many holes might be punctured in its bottom. On the top of the deck there will be walls 14 ft. high, sustaining a roof, and within this house the barge will have a capacity of 526 tons of freight. As the capacity of the river boats plying between Sacramento and San Francisco is but 150 to 300 tons, the owners of the barge expect to be able to lower the freight rates. The barge will be transported by tug power. All future barges will be built along the same lines.—*Cement Age.*

Steel Hoisting Towers.—Steel hoisting towers erected alongside buildings for hoisting concrete are being used at Lowell on the new warehouse for the Massachusetts Cotton Mills. They are made in interchangeable sections, each 10 ft. 9 in. high, and are said to be rigid enough for heights of over 100 ft. They consist of 4 in. by 4 in. by ⅜ in. upright corner angles and 2½ in. by 2½ in. by ¼ in. angles for diagonals and braces. The guides for the automatic dumping concrete bucket are 5-in. channels. The bucket can be arranged to tip at any panel to suit the floor elevation. Each section is divided into two panels by an intermediate horizontal brace, and the horizontals at top and bottom of the section have their flanges out, thus giving bearing for adjacent sections. In each section holes are punched in the uprights so that the derrick can be placed at any height. On one side of the tower is a ladder, also of steel. The towers delivered to the job ready for erection are said to have cost £100 each.—*Engineer.*

Sawdust Concrete.—When sawdust or wood pulp is used as part of the aggregate in mixing the resulting concrete is of light weight and low tensile strength, but has some special properties that commend it for certain indoor uses. On account of its elasticity, combined with its practically non-absorbent character, it is especially adapted as a floor veneering for markets, butcher shops, saloons, etc. It may be laid without joints in a continuous layer 1½ in. deep upon paper spread over the floor that is being treated. In these cases the customary proportions for mixing are 1 part cement, 2 sand, and 2½ sawdust. A greater proportion of sawdust than this would make the concrete too absorbent.

A novel application of sawdust concrete has recently been made in the new public library building in Springfield, Mass. It was employed here as a base on which to lay the cork carpet covering the floors. The object was to obtain a layer into which nails could be driven, and which at the same time would hold the nails. The company that laid it states that it accomplished both purposes. After several experiments with different mixtures it was found that a 1 : 2 : ¾ mix—three-fourths of a part of sawdust—gave the desired result, and 5,000 sq. ft. of this mixture were laid. The thickness of the layer was 1 in., and after four months of service indications are that the material is a success.—*Cement World.*

New Supper-Room at Dublin Castle.—In connection with the improvements which are being carried out at Dublin Castle, the chief feature is a permanent new supper room, the foundations for which are to be concrete reinforced with expanded metal. The apartment will be about 80 ft. long and 40 ft. wide. The building operations are being carried out by Messrs. H. I. Martin, under the supervision of H.M. Office of Works. The decorations are being executed by Messrs. Dockrell Sons, Ltd.

Proposed Widening of Newport High Street.—The Newport Town Council at a recent meeting decided to widen the High Street to 40 ft. when the necessary land can be acquired. It was decided the widening should be covered with reinforced concrete.

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Reinforced Cement Building.—The first house ever built in Europe of reinforced cement has just been completed in Haarlem.

The interesting feature in connection with the construction of the building is that, strictly speaking, it was not built at all, but was cast in a single piece. An iron mould was erected, and into this the cement was poured. As soon as this had hardened the iron casing was removed, and the house was ready for the placing of the roof and the interior fittings.

Separator for Concrete Wall Moulds.—An ingenious and at the same time simple type of separator for concrete wall moulds, as described by an American contemporary, consists of a concrete tube made in standard lengths of 4 in., 5 in., 6 in., and 8 in., each having a ⅞-in. diameter hole from end to end, giving ample clearance for a ⅜-in. bolt, passed through the tube and the timbering on each side. The separators are moulded of good quality concrete, and after the wall has been built they are left in place, and become an integral part of the structure. The holes can be allowed to remain open for the support of temporary scaffolding, and afterwards closed by cement mortar. An advantage claimed for the new form of separator, in addition to its general convenience, is that no rust streaks are caused, as is sometimes noticed where iron separators are employed.

A Recent Test on Lock-Woven Mesh.—A test has recently been carried out, according to *The Builder*, on Messrs. Tozer and Sons lock-woven mesh reinforcement. The test was conducted on a concrete slab reinforced with lock-woven mesh under the auspices of the Institute of Architects of New South Wales at the Technical College, Ultimo. The slab, which was made under the supervision of Mr. James Nangle, F.I.A., F.R.A.S., was composed of five shivers, 2 Nepean sand, 1 Portland cement. The thickness of the slab was 6 in. ; span, 8 ft. ; width, 4 ft. ; age of slab, 30 days ; depth, from top of slab to centre of steel, 5 in. ; sectional area of steel, ·5499 sq. in. The slab was loaded with bricks, each layer consisting of 100 bricks, with bolts spaced sufficiently far apart to prevent any probability of arching. With a load of 168 lb. per sq. ft. the deflectometer showed a deflection in the slab at the centre of the span of ·015 in. The load was then taken off, and the slab returned to zero. This gives a good illustration of the elasticity of the slab and the reinforcement when we bear in mind that the live load calculated for was only 56 lb. per foot, with a factor of safety of 4, and the slab was thus loaded to about three times its live load. Immediately following this test, the slab was loaded for a breaking strain, and particular interest was taken to see whether, when the load reached its previous amount, the deflection would be increased owing to the excessive stresses produced by the first test. Such was not the case, however, for with the same load—viz., 168 lb. per sq. ft.—the deflectometer showed exactly the same deflection of ·015 in.

Further loadings produced greater deflections, as shown on table below :

Load. Lb. per sq. ft.	Deflection. In.
224	·02
267	·115
281	·18
309	·2
338	·27
366	·33

With the load finally at 407·74 lb. per sq. ft. the slab broke, a crack developing at 2 ft. 4 in. from one end, thus denoting that the steel had been stressed up to its elastic limit, and that it had commenced to stretch. From this we see that the test came out highly satisfactory, the slab developing a total bending moment of 182,016 in. lb. against the theoretical bending moment of 158,471 in. lb.

Waterproof Reservoirs.—Four waterproofed reservoirs, built by the El Paso South-Western Railway a year ago, have given satisfactory service as the result of surface treatment of the concrete linings. The depth of water is 12 ft. Soap and alum were first used in coating the lining, which was 4 in. to 6 in. thick. Two coats of each were applied, beginning with the soap, and alternating. Hot asphalt or cold prepared asphalt paint was then put on the surface. Some trouble was experienced in making the asphalt adhere permanently, probably owing to the fact that the surface was smooth and glossy as a result of the alum and soap treatment. The prepared asphalt paint adhered more firmly, however, and proved generally satisfactory. The work was done on the basis that dense concrete rich in cement is the primary requisite for water-tightness. The treatment was selected after tests to determine the qualities of the soap and alum solutions and the asphalt and paint.—*Engineer.*

TRADE NOTICES.

Indented Bar and Concrete Engineering Co.—We are informed that the name of the Patent Indented Steel Bar Co., Ltd., has been altered to the Indented Bar and Concrete Engineering Co., Ltd. The business of the firm will not be altered, but will be carried on under the new name at the same address, Queen Anne's Chambers, Westminster.

EDITORIAL MEMOS.

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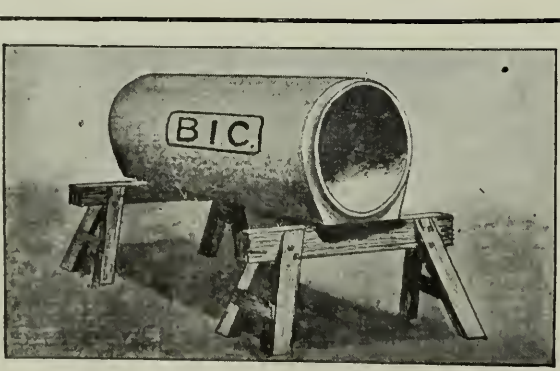

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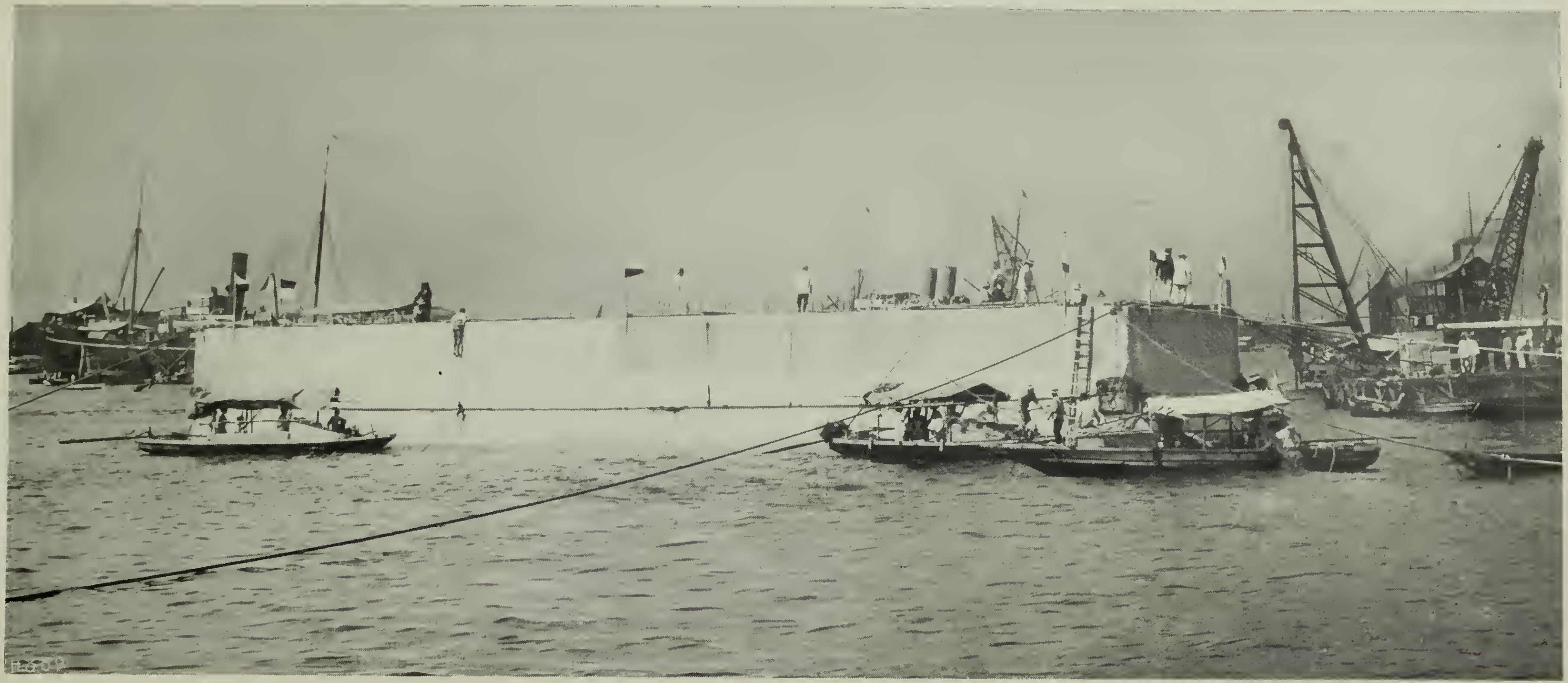

Reinforced Concrete Caisson in position ready for sinking.
Kobe Harbour Improvements.

(Frontispiece.)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume VI. No. 8. LONDON, AUGUST, 1911.

EDITORIAL NOTES.

THE SECOND REPORT OF THE JOINT COMMITTEE ON REINFORCED CONCRETE.

IT is with the greatest pleasure that we announce the issue of the Second Report of the Joint Committee on Reinforced Concrete, which was formed under the auspices of the Royal Institute of British Architects, and whose first momentous statement was issued in 1907.

Since that year the progress made in the use of reinforced concrete in the British Empire has been remarkable, and, generally speaking, the work executed has been eminently successful, and in many instances economical. As with all new materials, it has been frequently badly applied, and in some cases the ignorance displayed both in design and execution have been quite as remarkable as when other new materials have been introduced during the past century. It is in order to avoid the errors of the ignorant and inexperienced that a report such as that of the Joint Committee is particularly valuable. It is a guide to those who, not being controlled by specific regulations, are all too often inclined to take undue risks, or to adopt the attitude of *laissez-faire.*

Apart from serving as a guide, a report of this description materially strengthens the hands of the advocates of reinforced concrete, as it is a useful document which can be put forward when doubts are expressed as to reinforced concrete in a general sense, or where public authorities and employers like to know that their advisers are not acting on their own responsibility alone, but that they have some fairly authoritative expression of opinion to go upon.

The second report now before us is obviously an improvement on the first, and, as its introductory note indicates, this may be ascribed probably to the fact that the use and knowledge of the material have steadily increased ; but, apart from this, we think the improvement is also probably due to a lessening of certain prejudices and a wider grasp of the subject which have come with the efflux of time.

The weakest spot in the report is that its signatories are not as representative of the technical professions concerned as we would have wished. They are as representative certainly as in the first report, and even more so, as they now include representatives of the London County Council and of the Concrete Institute, but the Royal Institute of British Architects, the District Surveyors' Association, the Institute of Builders, the Association of Municipal and County Engineers, even when supplemented by delegates from the War Office and Admiralty and by the two bodies first named, scarcely constitute as representative a combination of technical knowledge as could be desired. Surely the principal body in all affairs relating to engineering is the Institution of Civil Engineers, and no matter how slowly that body may have moved, and how conservative its views may be at times, no expression of thought concerning technical problems can be really considered authoritative when that body stands apart. Of course, it may be pointed out to us that the representatives include some engineers, but, excepting Professor Unwin, with Mr. C. H. Colson, of the Admiralty, and Mr. W. G. Kirkaldy of testing fame, the engineering talent is not characteristic of the current age of great engineering works. Where, we would ask, are the men who have made Great Britain's name famous in civil engineering work in the past 25 years ? Of course, we are fully aware that in the early days of reinforced concrete there may have been some misunderstanding between the Royal Institute of British Architects and the Gt. George Street institution as to the representation of the latter body on the Joint Committee, but the time is surely past for all this. The Institution of Civil Engineers even has its own reinforced concrete sub-committee at work at the present moment, and it is regrettable indeed that the differences should not have been overcome, as they militate so greatly against the value of this useful piece of work.

What we have remarked concerning the Institution of Civil Engineers also holds good in a certain degree to the Iron and Steel Institute, the Institute of Chemistry, and the British Fire Prevention Committee. Steel plays such an important *rôle* in reinforced concrete that its premier institute should certainly have been represented. Chemistry also has a high position, and should not have been overlooked, whilst the fire risk occupies an important and economic place, and is, as a matter of fact, accorded considerable space in the third clause of the report. To put it quite plainly, the Joint Committee is a very useful one as far as it goes, but it does not represent the whole of those technical interests which should have a voice in the matter.

As in 1907, we are publishing the main part of the report, and it is our intention to take up certain of the scientific and technical questions in succeeding numbers of this journal. We would here say that, even if some of the points brought out are eminently contentious, they do not appear to contain anything that is, in our view, seriously wrong. The appendices that have been added are certainly worthy of attention.

Regarding the Standard Notation, which has been appended in a useful form, we are glad to observe that the notation proposed by the Concrete Institute has been adopted, for even if we cannot obtain an international notation, it is well, indeed, that the effort to standardise the notation in reinforced concrete in the British Empire should continue, and it greatly facilitates matters when bodies such as the Joint Committee adopt what the Concrete Institute has proposed.

Speaking generally, the second report merits the attention of all interested in concrete and reinforced concrete. It is a valuable piece of work, and most useful as far as it goes, and we think it is a necessary addition to the library of all those interested in the new material.

SECOND REPORT OF THE JOINT COMMITTEE ON REINFORCED CONCRETE

Formed under the auspices of THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

The long-expected Second Report of the Joint Committee on Reinforced Concrete formed by the Royal Institute of British Architects has just been published, and we now present it, with its "Prefatory Note," and the "Standard Notation," but without the Appendices. The Notation given should serve as a useful guide to all concerned in getting out calculations for reinforced concrete work.—ED.

WE are presenting herewith the Second Report of the Joint Committee on Reinforced Concrete, formed under the auspices of the Royal Institute of British Architects, together with the key to the notation, but excepting the appendices, and we would here remark that the complete second report can be obtained at the offices of the Joint Committee, Royal Institute of British Architects, 9 Conduit Street, Regent Street, London, W., at the price of 1s. It should form an absolute essential in the library of anyone interested in the subject.

We would preface the report by giving the constitution of the Joint Committee, which is as follows:

Chairman: Sir Henry Tanner, C.B., I.S.O., R.V.O., F.R.I.B.A., President Concrete Institute.

Vice-Chairman: Professor W. C. Unwin, F.R.S., Hon.A.R.I.B.A.

Representing the Royal Institute of British Architects: Max Clarke, F.R.I.B.A.; William Dunn, F.R.I.B.A.; A. T. Walmisley, M.Inst.C.E.; H. D. Searles-Wood, F.R.I.B.A., hon. sec.

Representing the District Surveyors' Association.—E. Dru Drury, F.R.I.B.A.; Thomas Henry Watson, F.R.I.B.A.

Representing the Institute of Builders: Benjamin I. Greenwood, Frank May, J.P.

Representing the Municipal and County Engineers' Association: J. W. Cockrill, M.Inst.C.E.; A. E. Collins, M.Inst.C.E.

Representing the War Office: Captain J. Gibson Fleming, R.E., Assoc.Inst.C.E.

Representing the Admiralty: C. H. Colson, M.Inst.C.E.

Representing the London County Council: Frank Capon; E. Fiander Etchells, F.Phys.Soc., A.M.I.Mech.E.

Representing the Concrete Institute: Charles F. Marsh, M.Inst.C.E., M.Am.Soc.C.E.; William G. Kirkaldy, A.M.Inst.C.E.

In the explanatory note the Joint Committee say that their Section on Materials has been modified in certain details as compared with the report of 1907. The Section on Methods of Calculation has been recast in form, and the standard notation proposed by the Concrete Institute has been adopted. The sub-section on Columns has been revised, and the formulæ proposed have been recast so as to include the cases in which the lateral or helical binding is a material factor in the strength.

There are eight appendices to the report, and their titles are as follows :

Calculations for Singly Reinforced Beams. By Captain J. G. Fleming, R.E.

Shear Stresses in Reinforced Concrete Beams. By William Dunn, F.R.I.B.A.

The Strength of Rectangular Slabs. By E. F. Etchells, F.Phys.Soc.

Strength of Pillars. By E. F. Etchells, F.Phys.Soc.

The Moment of Inertia of Sections of Reinforced Concrete. By W. C. Unwin, F.R.S., Hon.A.R.I.B.A.

Tensile and Shearing Stresses in Web Reinforcement. By E. F. Etchells, F.Phys.Soc.

Bach's Theory of the Resistance of Flat Slabs Supported on all Edges and Uniformly Loaded. By W. C. Unwin, F.R.S.

Comparison of the Results Given by Various Rules for the Strength of Flat Rectangular Slabs Supported on all Edges and Uniformly Loaded. By William Dunn, F.R.I.B.A.

SECOND REPORT.

PREFATORY NOTE.

1. Reinforced concrete is used so much in building and engineering construction that a general agreement on the essential requirements of good work is desirable. The proposals which follow are intended to embody these essentials, and to apply generally to all systems of reinforcement.

Good workmanship and materials are essential in reinforced concrete. With these and good design structures of this kind appear to be trustworthy. It is essential that the workmen employed should be skilled in this class of construction. Very careful superintendence is required during the execution of the work in regard to—

(*a*) The quality, testing, and mixing of the materials.

(*b*) The sizes and positions of the reinforcements.

(*c*) The construction and removal of centering.

(*d*) The laying of the material in place and the thorough punning of the concrete to ensure solidity and freedom from voids.

If the metal skeleton be properly coated with cement, and the concrete be solid and free from voids, there is no reason to fear decay of the reinforcement in concrete of suitable aggregate and made with clean fresh water.

2. The by-laws regulating building in this country require external walls to be in brick, or stone, or concrete of certain specified thicknesses. In some places it is in the power of the local authorities to permit a reduced thickness of concrete when it is strengthened by metal ; in other districts no such power has been retained. We are of opinion that all by-laws should be so altered as to expressly include reinforced concrete amongst the recognised forms of construction.

A section should be added to the by-laws declaring that when it is desired to erect buildings in reinforced concrete, complete drawings showing all details of construction and the sizes and positions of reinforcing bars, a specification of the materials to be used and proportions of the concrete, and the necessary calculations of strength based on the rules contained in this report, signed by the person or persons responsible for the design and execution of the work, shall be lodged with the local authority.

3. *Fire Resistance.*—(*a*) Floors, walls, and other constructions in steel and concrete formed of incombustible materials prevent the spread of fire in varying degrees according to the composition of the concrete, the thickness of the parts, and the amount of cover given to the metal.

(*b*) Experiment and actual experience of fires show that concrete in which limestone is used for the aggregate is disintegrated, crumbles, and loses coherence when subjected to very fierce fires, and that concretes of gravel or sandstones also suffer, but in a rather less degree.* The metal reinforcement in such cases generally retains the mass in position, but the strength of the part is so much diminished that it must be renewed. Concrete in which coke-breeze, cinders, or slag forms the aggregate is only superficially injured, does not lose its strength, and in general may be repaired. Concrete of broken brick suffers more than cinder concrete and less than gravel or stone concrete.

(*c*) The material to be used in any given case should be governed by the amount of fire resistance required as well as by the cheapness of, or the facility of procuring, the aggregate.

(*d*) Rigidly attached web members, loose stirrups, bent-up rods, or similar means of connecting the metal in the lower or tension sides of beams or floor slabs (which sides suffer most injury in case of fire) with the upper or compression sides of beams or slabs not usually injured are very desirable.

(*e*) In all ordinary cases a cover of ½ in. on slabs and 1 in. on beams is sufficient. It is undesirable to make the covering thicker. All angles should be rounded or splayed to prevent spalling off under heat.

(*f*) More perfect protection to the structure is required under very high temperature, and in the most severe conditions it is desirable to cover the concrete structure with fire-resisting plastering which may be easily renewed. Columns may be covered with coke-breeze, concrete, terra-cotta, or other fire-resisting facing.

MATERIALS.

4. *Cement.*—Only Portland cement complying with the requirements of the specification adopted by the British Engineering Standards Committee should be employed ; in general the slow-setting quality should be used. Every lot of cement delivered should be tested, and in addition the tests for soundness and time of setting, which can be made without expensive apparatus, should be applied frequently during construction. The cement should be delivered on the work in bags or barrels bearing the maker's name and the weight of the cement contained.

5. *Sand.*—The sand should be composed of hard grains of various sizes up to particles which will pass a ¼-in. square mesh, but of which at least 75 per cent. should pass ⅛-in. square mesh. Fine sand alone is not so suitable, but the finer the sand the greater is the quantity of cement required for equal strength of mortar. It should be clean and free from ligneous, organic, or earthy matter. The value of a sand cannot always be judged from its appearance, and tests of the mortar prepared with the cement and the sand proposed should always be made. Washing sand does not always improve it, as the finer particles which may be of value to the compactness and solidity of the mortar are carried away in the process.

6. *Aggregate.*—The aggregate, consisting of gravel, hard stone, or other suitable material,† should be clean and preferably angular, varied in size as much as possible between the limits of size allowed for the work. In all cases material which passes a

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* The smaller the aggregate the less the injury.

† Coke-breeze, pan breeze, or boiler ashes ought not to be used for reinforced concrete. It is advisable not to use clinker or slag, unless the material is selected with great care.

sieve of a ¼-in. square mesh should be reckoned as sand. The maximum allowable size is usually ¾ in. The maximum limit must always be such that the aggregate can pass between the reinforcing bars and between these and the centering. The sand should be separated from the gravel or broken stone by screening before the materials are measured.

7. *Proportions of the Concrete.*—In all cases the proportions of the cement, sand, and aggregate should be separately specified in volumes. The amount of cement added to the aggregate should be determined on the work by weight. The weight of a cubic foot of cement for the purpose of proportioning the amount of cement to be added may be taken at 90 lb. As the strength and durability of reinforced concrete structures depend mostly on the concrete being properly proportioned, it is desirable that in all important cases tests should be made as described herein with the actual materials that will be used in the work before the detailed designs for the work are prepared.

In no case should less dry cement be added to the sand when dry than will suffice to fill its interstices, but subject to that the proportions of the sand and cement should be settled with reference to the strength required, and the volume of mortar produced by the admixture of sand and cement in the proportions arranged should be ascertained.*

The interstices in the aggregate should be measured, and at least sufficient mortar allowed to each volume of aggregate to fill the interstices and leave at least 10 per cent. surplus.

For ordinary work a proportion of one part cement to two parts sand will be found to give a strong, practically watertight mortar, but where special watertightness or strength is required the proportion of cement must be increased.

8. *Metal.*—The metal used should be steel having the following qualities :

(*a*) An ultimate strength of not less than 60,000 lb. per sq. in.

(*b*) A yield point of not less than 32,000 lb. per sq. in.

(*c*) It must stand bending cold 180° to a diameter of the thickness of pieces tested without fracture on outside of bent portion.

(*d*) In the case of round bars the elongation should not be less than 22 per cent., measured on a gauge-length of eight diameters. In the case of bars over 1 in. in diameter the elongation may be measured on a gauge-length of four diameters, and should then be not less than 27 per cent.

For other sectional material the tensile and elongation tests should be those prescribed in the British Standard Specification for Structural Steel. If hard or special steel is used, it must be on the architect's or engineer's responsibility and to his specification.

Before use in the work the metal must be clean and free from scale or loose rust. It should not be oiled, tarred, or painted.

Welding should in general be forbidden ; if it is found necessary, it should be at points where the metal is least stressed, and it should never be allowed without the special sanction of the architect or engineer responsible for the design.

The reinforcement ought to be placed and kept exactly in the positions marked on the drawings, and, apart from any consideration of fire resistance, ought not to be nearer the surface of the concrete at any point than 1 in. in beams and pillars and ½ in. in floor slabs or other thin structures.

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* For convenience on small works the following figures may be taken as a guide, and are probably approximately correct for medium silicious sand :

Parts Cement.		Parts Sand.		Parts Mortar	Parts Cement.		Parts Sand.		Parts Mortar.
1	+	½	=	1·20	1	+	2	=	2·35
1	+	1	=	1·50	1	+	2½	=	2·70
1	+	1½	=	1·90	1	+	3	=	3·00

9. *Mixing : General.*—In all cases the concrete should be mixed in small batches and in accurate proportions, and should be laid as rapidly as possible. No concrete which has begun to set should be used.

Hand-mixing.—When the materials are mixed by hand they are to be turned over dry and thoroughly mixed on a clean platform until the colour of the cement is uniformly distributed over the aggregate.

Machine-mixing.—Whenever practicable, the concrete should be mixed by machinery.

10. *Laying.*—The thickness of loose concrete that is to be punned should not exceed 3 in. before punning, especially in the vicinity of the reinforcing metal. Special care is to be taken to ensure perfect contact between the concrete and the reinforcement, and the punning to be continued till the concrete is thoroughly consolidated. Each section of concreting should be as far as possible completed in one operation ; * when this is impracticable, and work has to be recommenced on a recently laid surface, it is necessary to wet the surface ; and where it has hardened it must be hacked off, swept clean, and covered with a layer of cement mortar ½ in. thick, composed of equal parts of cement and sand. Work should not be carried on when the temperature is below 34° Fahr. The concrete when laid should be protected from the action of frost, and shielded against too rapid drying from exposure to the sun's rays or winds, and kept well wetted. All shaking and jarring must be avoided after setting has begun. The efficiency of the structure depends chiefly on the care with which the laying is done.

Water.—The amount of water to be added depends on the temperature at the time of mixing, the materials, and the state of these, and other factors, and no recommendation has therefore been made. Sea-water should not be used.

11. *Centering or Casing.*—The centering must be of such dimensions, and so constructed, as to remain rigid and unyielding during the laying and punning of the concrete. It must be so arranged as to permit of easing and removal without jarring the concrete. Provision should be made wherever practicable for splaying or rounding the angles of the concrete. Timber when used for centering may be advantageously limewashed before the concrete is deposited.

12. *Striking of Centres.*—The time during which the centres should remain up depends on various circumstances, such as the dimensions or thickness of the parts of the work, the amount of water used in mixing, the state of the weather during laying and setting, etc., and must be left to the judgment of the person responsible for the work. The casing for columns, for the sides of beams, and for the soffits of floor slabs not more than 4 ft. span must not be removed under eight days ; soffits of beams and of floors of greater span should remain up for at least 14 days, and for large span arches for at least 28 days. The centering of floors in buildings which are not loaded for some time after the removal of same may be removed in a short time ; the centering for structures which are to be used as soon as completed must remain in place much longer. If frost occurs during setting, the time should be increased by the duration of the frost.

13. *Testing.*—Before the detailed designs for an important work are prepared, and during the execution of such a work, test pieces of concrete should be made from the cement, sand, and aggregate to be used in the work, mixed in the proportions specified. These pieces should be either cubes of not less than 4 in. each way, or cylinders not less than 6 in. diameter, and of a length not less than the diameter. They should be prepared in moulds, and punned as described for the work. Not less

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* In particular the full thickness of floor slab should be laid in one operation.

than four cubes or cylinders should be used for each test, which should be made 28 days after moulding. The pieces should be tested by compression, the load being slowly and uniformly applied. The average of the results should be taken as the strength of the concrete for the purposes of calculation, and in the case of concrete made in proportions of 1 cement, 2 sand, 4 hard stone, the strength should not be less than 1,800 lb. per sq. in. Such a concrete should develop a strength of 2,400 lb. at 90 days.

Loading tests on the structure itself should not be made until at least two months have elapsed since the laying of the concrete. The test load should not exceed one and a half times the accidental load. Consideration must also be given to the action of the adjoining parts of the structure in cases of partial loading. In no case should any test load be allowed which would cause the stress in any part of the reinforcement to exceed two-thirds of that at which the steel reaches its elastic limit.

METHODS OF CALCULATION.

Data.

1. *Loads.*—In designing any structure there must be taken into account :

(*a*) The weight of the structure.

(*b*) Any other permanent load, such as flooring, plaster, etc.

(*c*) The accidental or superimposed load.

(*d*) In some cases also an allowance for vibration and shock.

Of all probable distributions of the load that is to be assumed in calculation which will cause the greatest straining action.

(i.) The weight of the concrete and steel structure may be taken at 150 lb. per cu. ft.

(ii.) In structures subjected to very varying loads and more or less vibration and shock, as, for instance, the floors of public halls, factories, or workshops, the allowance for shock may be taken equal to half the accidental load. In structures subjected to considerable vibration and shock, such as floors carrying machinery, the roofs of vaults under passage ways and courtyards, the allowance for shock may be taken equal to the accidental load.

(iii.) In the case of columns or piers in buildings which support three or more floors, the load at different levels may be estimated in this way. For the part of the roof or top floor supported, the full accidental load assumed for the floor and roof is to be taken. For the next floor below the top floor 10 per cent. less than the accidental load assumed for that floor. For the next floor 20 per cent. less, and so on to the floor at which the reduction amounts to 50 per cent. of the assumed load on the floor. For all lower floors the accidental load on the columns may be taken at 50 per cent. of the loads assumed in calculating those floors.*

Beams.

2. *Spans.*—These may be taken as follows :—For beams, the distance from centre to centre of bearings ; for slabs supported at the ends, the clear span + the thickness of slab ; for slabs continuous over more than one span, the distance from centre to centre of beams.

3. *Bending Moments.*—The bending moments must be calculated on ordinary statical principles, and the beams or slabs designed and reinforced to resist these moments. In the case of beams or slabs continuous over several spans or fixed at the ends, it is in general sufficiently accurate to assume that the moment of inertia of the section has a constant value.

Where the maximum bending moments in beams or floor slabs continuous over three or more equal spans and under uniformly distributed loads are not determined by exact calculation the bending moments should not be taken less than $+\frac{wl^2}{12}$ at the centre of the span and $-\frac{wl^2}{12}$ at the intermediate supports.

When the spans are of unequal lengths, when the beam or slab is continuous over two spans only, or when the loads are not uniformly distributed, more exact calculations should be made.

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* In the case of many warehouses and buildings containing heavy machines it is desirable not to make any reduction of the actual loads.

If the bending moments are calculated by the ordinary theory of continuous beams, it should be remembered that the supports are usually assumed level, and if this is not the case, or the supports sink out of level, the bending moments are altered.

4. *Stresses.*—The internal stresses are determined, as in the case of a homogeneous beam, on these approximate assumptions :

(*a*) The coefficient of elasticity in compression of stone or gravel concrete, not weaker than 1 : 2 : 4, is treated as constant, and taken at one-fifteenth of the coefficient of elasticity of steel.

	lb. per sq. in.
Coefficient for concrete $= E_c =$	2,000,000
,, ,, steel $= E_s =$	30,000,000

$$\frac{E_s}{E_c} = 15.$$

It follows that at any given distance from the neutral axis, the stress per sq. in. on steel will be fifteen times as great as on concrete.

(*b*) The resistance of concrete to tension is neglected, and the steel reinforcement is assumed to carry all the tension.

(*c*) The stress on the steel reinforcement is taken as uniform on a cross-section, and that on the concrete as uniformly varying. In the case of steel of large section it may be necessary to consider the stress as varying across the section.

5. *Working Stresses.*—If the concrete is of such a quality that its crushing strength is 1,800 lb. per sq. in. after 28 days as determined from the test cubes made in accordance with Clause 13, and if the steel has a tenacity of not less than 60,000 lb. per sq. in., the following stresses may be allowed :

	lb. per sq. in.
Concrete in compression in beams subjected to bending	600
Concrete in columns under simple compression	600
Concrete in shear in beams ...	60
Adhesion * or grip of concrete to metal	100
Steel in tension	16,000
Steel in compression— 15 times the stress in the surrounding concrete	
Steel in shear	12,000

When the proportions of the concrete differ from those stated above, the stress allowed in compression on the concrete may be taken at one-third the crushing stress of the cubes at 28 days as determined above.

If stronger steel is used, the allowable tensile stress may be taken at one-half the stress at the yield point of the steel, but in no case should it exceed 20,000 lb. per sq. in.

BEAMS WITH SINGLE REINFORCEMENT.

Beams with single reinforcement can be divided into three classes :

(*a*) Beams of T form in which the neutral axis falls outside the slab.

(*b*) Beams of T form in which the neutral axis falls within the slab.

(*c*) Rectangular beams.

The equations found for (*a*) are general equations, from which the equations for (*b*) and (*c*) may be deduced.

In the calculation of all beams, the area upon which the ratio of tensile reinforcement is taken is considered as a rectangle of breadth equal to the greatest breadth of the beam and of depth equal to the greatest effective depth of the beam.

In designing beams where the rib is monolithic with a slab, the beam may be considered to be of T form. The slab

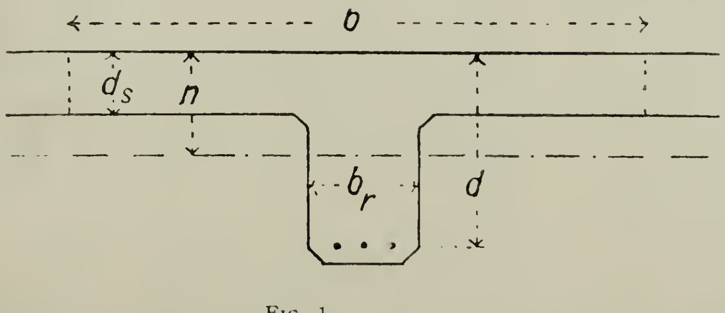

FIG. 1.

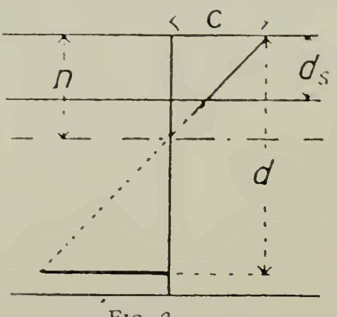

FIG. 2.

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* It is desirable that the reinforcing rods should be so designed that the adhesion is sufficient to resist the shear between the metal and concrete. Precautions should in every case be taken by splitting or bending the rod ends or otherwise to provide additional security against the sliding of the rods in the concrete.

must first be calculated and designed having its own reinforcing bars transverse to the rib. The whole of the slab cannot in general be considered to form part of the upper flange of the T beams. The width, b, of the upper flange may be assumed to be not greater than one-third the span of the beams, or more than three-fourths of the distance from centre to centre of the reinforcing ribs or more than fifteen times the thickness of slab. The width b of the rib should not be less than one-sixth of the width b_r of the flange.

(a) Beams of T section where the neutral axis falls outside the slab.

In this case the small compression in the rib between the underside of the slab and the neutral axis may be neglected. In a homogeneous beam the stresses are proportional to the distances from the neutral axis. In a discrete beam, such as a beam of concrete and steel, on account of the greater rigidity of steel, at a given distance from the neutral axis the stress in the steel will be m times as great as in concrete.

Hence

$$\frac{mc}{t} = \frac{n_1 d}{d(1-n_1)} = \frac{n_1}{1-n_1}$$

$$\frac{c}{t} = \frac{n_1}{m(1-n_1)}.$$

The mean compressive stress in the flange is

$$\tfrac{1}{2}\left\{c + c\frac{n-d_s}{n}\right\} = \frac{c}{2}\cdot\frac{2n-d_s}{n}$$

$$= c\left(1 - \frac{s_1}{2n_1}\right)$$

and the total compression is

$$bd_s\frac{c}{2}\cdot\frac{2n-d_s}{n}.$$

The area of reinforcement $A_t = rbd$ and the total tension is

$$trbd$$

Equating total compression and total tension

$$bd_s\frac{c}{2}\cdot\frac{2n-d_s}{n} = trbd$$

$$\frac{c}{t} = \frac{2rn_1}{(2n_1-s_1)s_1}.$$

Equating these two values for $\frac{c}{t}$

$$\frac{n_1}{m(1-n_1)} = \frac{2rn_1}{(2n_1-s_1)s_1}$$

$$n = \frac{s_1^2+2mr}{2(s_1+mr)}.$$

The value of the lever arm is

$$d - \frac{d_s}{3}\,\frac{3n-2d_s}{2n-d_s}.$$

$$= d\left[1 - \frac{s_1}{3}\left(\frac{3n_1-2s_1}{2n_1-s_1}\right)\right]$$

The compressive resistance moment of the beam is

$$R_c = cbdd_s\frac{(s_1^3+4mrs_1^2-12mrs_1+12mr)}{6(s_1^2+2mr)}.$$

The tensile resistance moment is

$$R_t = tbd^2\frac{(s_1^3+4mrs_1^2-12mrs_1+12mr)}{6m(2-s_1)}.$$

To obtain stresses in the concrete and steel equal to c and t respectively, r must have a value

$$\frac{2mcs_1-mcs_1^2-ts_1^2}{2mt}.$$

When r exceeds the value given by this equation, the equation to R_c must be used in determining the moment of resistance. When r is less than the above value the equation to R_t must be used.

The following equation gives the value for r, which causes the neutral axis to be at the underside of the slab :

$$r = \frac{s_1^2}{2m(1-s_1)}.$$

(b) When the neutral axis falls within the slab, or is at the bottom edge of the slab, the equations for values of n_1, R_c, and R_t can be simplified, and become

$$n_1 = \sqrt{(m^2r^2+2mr)} - mr.$$

$$R_c = \frac{cbd^2n_1}{2}\left(1-\frac{n_1}{3}\right).$$

$$R_t = trbd^2\left(1-\frac{n_1}{3}\right).$$

To obtain stresses in the concrete and steel equal to c and t respectively

$$r \text{ must equal } \frac{mc^2}{2t(mc+t)}.$$

(c) For rectangular beams, not of T form, the equations given for T beams under (b) apply.

The ratio of reinforcement may be taken on any other suitable sectional area if the formulæ are modified in accordance.

Slabs Supported or Fixed on More than Two Sides.

It does not appear that there is either a satisfactory theory or trustworthy experiments from which the strength of rectangular slabs supported or fixed on all four edges can be determined. [*Appendices to the report give a statement of some rules which have been used in determining the strength of slabs.*]

SHEAR REINFORCEMENT.

It is always desirable to provide reinforcement to resist the shearing and diagonal tension stresses in reinforced concrete beams. The diagonal tension stresses depend on the vertical and horizontal shear, and also on the longitudinal tension at the point considered. As the longitudinal tension in the concrete at any given point is very uncertain, the amount and direction of the diagonal tension cannot be exactly determined.

It is the general practice to determine the necessary reinforcement by taking the vertical and horizontal shearing only into consideration.

The following equations may be used to determine the necessary resistance to shearing.

When S, the total shear in lb. at a vertical section, does not exceed $60ba$, no shear reinforcement is required.*

When S exceeds $60ba$, vertical shear members may be provided to take the excess and proportioned by the following rule :

$$\frac{A_s \cdot s_s \cdot a}{p} = S - 60ba$$

or

$$A_s = \frac{(S - 60ba)\,p}{a\,s_s};$$

where s_s is the unit resistance of the steel to shearing, and p is the pitch, or distance apart of the vertical shear members or groups of shear members, of area A_s.

In the case of T beams, b_r should be substituted for b.

In important cases, when extra security is required, the resistance of the concrete to shear, represented by $60ba$, should be disregarded.

When the shear members are inclined at an angle of about 45° to the horizontal, the area A_s may be decreased in the proportion of $\frac{1}{\sqrt{2}}$.

These equations, though based on somewhat uncertain assumptions, give reasonable results. But experience shows that :

(*a*) In general, floor slabs require no special reinforcement against shearing, and that the bending up of alternate bars near the end is sufficient.

(*b*) In beams, especially in T beams, shearing reinforcement should be provided at distances apart not exceeding the depth of the beam.

(*c*) It is desirable to bend up one or more of the bars of the tension reinforcement near the supports. When bent at an angle of about 45° the effect of this may be taken into account in the manner set out above ; when bent at a small angle to the horizontal the effect is very indeterminate.

(*d*) As the resistance of the shear members to the pull depends on the adhesion, and the anchorage at the ends, it is desirable to use bars of small diameter, and to anchor the stirrups at both their ends. In all cases the stirrups must be taken well beyond the centre of compression.

PILLARS AND PIECES UNDER DIRECT THRUST.

Definitions.

The length is to be measured between lateral supports (neglecting ordinary bracketing).

The effective diameter of a pillar means the least width and should be measured to the outside of the outermost vertical reinforcement.

The effective area of a pillar means the area contained by the outermost lateral reinforcement, and should be measured to the outside of the outermost vertical reinforcement.

Loading and Length of Pillars.

If the load is strictly axial the stress is uniform on all cross-sections.

Lateral bending of the pillar as a whole is not to be feared, provided :

(*a*) That the ratio of length to least outside diameter does not exceed 18.

(*b*) That the stress on the concrete does not exceed the permissible working stress for the given pillar.

(*c*) That the load be central.

(*d*) That the pillar be laterally supported at the top and base.

Construction.

Lateral reinforcement properly disposed raises the ultimate strength and increases the security against sudden failure, by preventing the lateral expansion of the concrete and the sudden disruption of the pillar.

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* The value of Sp is shown in the appendix to be $\frac{B_1 - B_2}{a}$.

Practical considerations lead to the addition of longitudinal bars, and the formation of an enveloping network of steel.

The total cross-sectional area of the vertical reinforcement should never be less than 0·8 per cent. of the area of the hooped core.

There should be at least six vertical bars when curvilinear laterals are used, and four for square pillars having rectilinear laterals.

In the case of rectangular pillars in which the ratio between the greater and the lesser width (measured to the outside of the vertical bars) exceeds one and a half, the cross-section of the pillars should be subdivided by cross-ties; and the number of vertical bars should be such that the distance between the vertical bars along the longer side of the rectangle should not exceed the distance between the bars along the shorter side of the rectangle.

The most efficient disposition of the lateral reinforcement would appear to be in the form of a cylindrical helix, the pitch or distance between the coils being small enough to resist the lateral expansion of the concrete.

Jointed circular hoops as ordinarily made are apparently not quite so efficient.

Rectilinear ties are still less adapted to resist the lateral or radial expansion of a highly stressed core.

The volume of curvilinear laterals should never be less than 0·5 per cent. of the volume of hooped core.

The diameter of rectilinear laterals should not be less than three-sixteenth of an inch.

STRENGTH.

The amount of the increase of strength in hooped pillars depends upon:

1. The *form* of hooping (whether curvilinear or rectilinear, etc.).
2. The *spacing* or distance between the hoops.
3. The *quantity* of hooping relative to the quantity of concrete in the core of the pillar.
4. The *quality of the concrete*.

Consequently the increase of strength may be shown to be equal to the product of the four factors ($u.f.s.r$).

u = the *ultimate* compressive stress on concrete not hooped (per unit of area).
f = a *form* factor or constant which will vary according to whether the hooping is curvilinear or rectilinear, etc.
s = *Spacing* factor or constant which will vary with the pitch of the laterals.
V_h = *Volume* of hooped reinforcement in cubic inches.
V = *Volume* of hooped core in cubic inches.
$r = V_h/V$ = the *ratio* of volumes—*i.e.*, the *ratio* of the volume of *helical* or horizontal reinforcement to the volume of hooped core.

The *ultimate* compressive stress on concrete *not hooped* being $= u$, and the increase of strength due to hooping being

$$u.f.s.r,$$

the total resistance of the hooped material per unit of area will then be

$$= u + u.f.s.r$$
$$= u[1 + f.s.r].$$

Let c_p = the working *compressive* stress on a *prism* of concrete (not hooped) $= W_F u$

W_F = the working factor $= c_p/u$,

Then the safe compressive stress on the hooped core $= c$, where

$$c = W_F u[1 + f.s.r]$$
$$= c_p[1 + f.s.r].$$

The values of f, s and their product may be obtained from the following table:

Form of Lateral Reinforcement.	Form Factor $=f$	Spacing of Laterals in Terms of Diameter of Hooped Core.	Spacing Factor $=s$	Value of $f\,s$
Helical .	1	0·2*d*	32	32
,, .	1	0·3*d*	24	24
,, .	1	0·4*d*	16	16
Circular Hoops .	0·75	0·2*d*	32	24
,, .	0·75	0·3*d*	24	18
,, .	0·75	0·4*d*	16	12
Rectilinear	0·5	0·2*d*	32	16
,,	0·5	0·3*d*	24	12
,,	0·5	0·4*d*	16	8
,,	0·5	0·5*d*	8	4
,,	0·5	0·6*d*	0	0

Let p = the pitch of the laterals in inches [*i.e.*, the axial spacing of the laterals].
d = the effective diameter of the hooped core in inches.

The spacing factor should not be taken at more than 32, even if p is less than $\cdot 2d$, but intermediate values of the spacing factor may be obtained from the equation

$$s = 48 - 80\frac{p}{d}$$

It will be seen from the above table that the advantage of hooping disappears with an increase in the spacing of the laterals, irrespective of the volume of hooping or the value of r.

Before the safe stress on the hooped core can be obtained it will be necessary to give values to W_F and $_u$. A table for this purpose will be found below.

The value of the working compressive stress on the concrete of the hooped core having been obtained, the maximum permissible pressure or load may be obtained from the equation

$P = c[A + (m - 1)A_v]$, where
A = the effective *area* of the pillar.
$m = \frac{E_s}{E_c}$ = *modular* ratio.
A_v = *Area* of *vertical* reinforcement.
P = total safe *pressure* on pillar.

Working Stresses.

A safety factor of 4 at 90 days is recommended for all pillars.

The following table of working stresses is suitable if good materials are used, and is based on the assumption that test cubes have *at least* the strength given at the periods stated :

Table Showing the Value of u and c_p for Pillars.

Proportions of Concrete Measured by Volume.	Pounds of Cement to $13\frac{1}{2}$ cu. ft of Sand and 27 cu. ft. of Shingle or Broken Stones.	Value of u at 28 days in pounds per sq. in.	Value of u at 90 days in pounds per sq. in.	Value of c_p at 90 days in pounds per sq. in. (Safety factor=4) (Working factor= 1/4).
1 : 2 : 4	610	1,800	2,400	600
1 : $1\frac{1}{2}$: 3	810	2,100	2,800	700
1 : 1 : 2	1,220	2,700	3,600	900

It is assumed that the tests of the strength of the concrete are made on unrammed cubes and of the same consistency as the concrete used on the work.*

Limitations of Stress on Pillars.

The following limits of stress should be observed in pillars :

(*a*) The stress on the metal reinforcement (*i.e.*, the value of $m.c$) should not exceed 0·5 of the yield point of the metal ;

(*b*) Whatever the percentage of lateral reinforcement the working stress on the concrete of pillars should not exceed $(0{\cdot}34 + 0{\cdot}32\,f)\,u$ where

f = *form* factor.
u = *ultimate crushing* resistance of the concrete.

Form of Laterals	Form Factor	Value of $(0{\cdot}34 + 0{\cdot}32f)\,u$
Rectilinear	0·5	$0{\cdot}5\,u$
Independent Circular Hoops	0·75	$0{\cdot}58\,u$
Helical	1·00	$0{\cdot}66\,u$

If these limits are adopted, the working stress on hooped concrete will always fall within the " limit of continued endurance " for plain concrete.

PILLARS ECCENTRICALLY LOADED.

If a pillar initially straight is loaded eccentrically, as when a beam rests on a bracket attached to the pillar, it may be regarded as fixed at the base and free at the loaded end. Then it must bend in the plane passing through the load, the *deflection* at the top being d_n. Let e be the *eccentricity* of the load measured from the centre of the pillar when straight. Then the bending moment at the base of the pillar is $W(d_n + e)$. But it is known that d_n will be small compared with e, provided that W is small compared with $2EI/l^2$, and this will be the case in such conditions as are likely to occur in designing concrete pillars. Then the bending moment may be taken as We, and the extreme " *fibre* " stress at the edge of the base of the pillar, treating it as homogeneous, will be

$$f = W\left\{\frac{1}{A} \pm \frac{e}{S_m}\right.$$

very nearly, where A is the whole section of the pillar and S_m the *section modulus* relatively to an axis through the centre of gravity and at right angles to the plane of bending.

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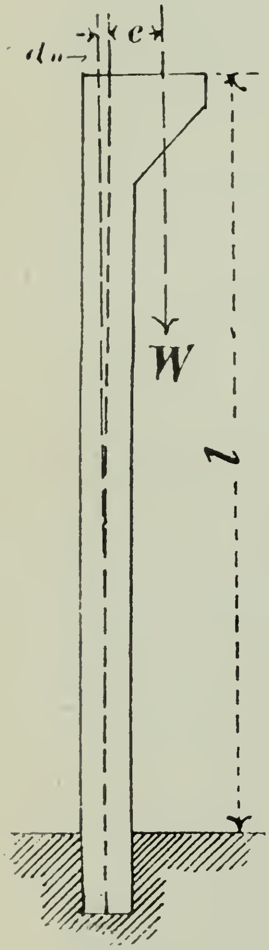
* The limit of 2,400 lb. per sq. in. given in the previous report of the Committee was adopted on the assumption that the cubes would be rammed with iron rammers under laboratory conditions.



In dealing with reinforced pillars which are not homogeneous, it is convenient to substitute for the actual section of the pillar what may be termed the equivalent section, or section of concrete equivalent in resistance to the actual pillar. If A is the effective area of section of the pillar (including the area of reinforcement), and A_V is the *area* of *vertical* reinforcement, then the equivalent section is

$$A_E = A + (m-1)A_V.$$

If d is the *depth* of the section in the plane of bending, the Inertia moment relatively to the neutral axis can be expressed in the form

$$I = nAd^2,$$

and the section modulus in the form $S_m = 2nAd$. (*See Appendix V. of the report*)

It is desirable in pillars that there should be no tension, and generally when the vertical load is considerable there is none. Cases in which the eccentricity is so great that there is tension must be treated by the methods applicable to beams if it is made a condition that the steel carries all the tension. In the following cases it is assumed that there is no tension.

Case I. — Pillar of Circular Section, Reinforcements Symmetrical and Equidistant from the Neutral Axis. — Let m be the modular ratio $= Es/E$, A the effective cross-section of the column in square inches, A_V the area of vertical reinforcement in square inches, d the *diameter* of the pillar, d_v the *distance* between the *vertical* reinforcing bars perpendicular to the neutral axis. Then the equivalent section is

$$A_E = A + (m-1)A_V,$$

and the section modulus is (*Appendix V. of the report*)

$$S_m = \tfrac{1}{8}Ad + \tfrac{1}{2}(m-1)A_V\frac{d_v^2}{d}.$$

The stress at the edges of the section can then be calculated by the general equation

$$f = W\left\{\frac{1}{A} \pm \frac{e}{S_m}\right\}$$

where e is the eccentricity of the load in inches and W the weight or load in lb. The greater value of stress must not exceed the safe stress stated above.

Case II.—Rectangular Section with Reinforcement Symmetrical and Equidistant from the Neutral Axis.—Using the same notation as in the last case, d being now the *depth* of the section in the plane of bending, the section modulus is (*Appendix V. of the report*)

$$S_m = \tfrac{1}{6}Ad + \tfrac{1}{2}(m-1)A_V\frac{d_v^2}{d},$$

and the stresses are given by the same equation as in the previous case.

Case III.—Column of Circular Section with Reinforcing Bars Arranged in a Circle.—Using the same notation as in Case I., h_t being the diameter of the circle of reinforcing bars, the section modulus is (*Appendix V.*)

$$S_m = \tfrac{1}{8}Ad + \tfrac{1}{4}(m-1)A_V\frac{d_v^2}{d},$$

and the stresses are given by the same equation as in Case I.

(*c*) *Long Pillars Axially Loaded.*

For pillars more than 18 diameters in length there is risk of lateral buckling of the pillar as a whole. The strength of such pillars would be best calculated by Gordon's formula, but there are no experiments on long pillars by which to test the values of the constants for a concrete or concrete and steel pillar. There does not seem, however, to be any probability of serious error if the total load is reduced in a proportion inferred from Gordon's formula to allow for the risk of buckling.

Let, as before, A = the *area* of the column in inches ; A_V = the *area* of *vertical* reinforcement. Then $A_E = A + (m-1)A_V$ is the equivalent section. Let N be the *numerical* constant in the equation, $I = NAd^2$ (*Appendix V.*), and d the least diameter of the pillar.

Then for a pillar fixed in direction at both ends Gordon's formula is

$$\frac{W}{A_u} = \frac{1}{1+\dfrac{l^2}{C_1Nd^2}} = \frac{1}{1+C_2}$$

so that the pillar will carry less than a short column of the same dimensions in the ratio of $1+C_2$ to 1, or, in other words, the column will be safe if calculated as a short column, not for the actual weight or pressure P, but for a weight or pressure $=(1+C_2)W$.

The constant C_1 has not been determined experimentally for reinforced long columns. But its probable value is

$$C_1=\frac{4\pi^2E_C}{u}$$

where u is the *ultimate* crushing stress. Putting $E_C=2{,}000{,}000$ and $u=2{,}500$, then $C_1=32{,}000$. Looking at the well-understood uncertainty of the rules for long columns, very exact calculation is useless. Some values of N for ordinary types of column are given in Appendix V.

Taking these values, the following are the values of $1+C_2$:

VALUES OF $1+C_2$.

	Case I.	*Case II.*	*Case III.*
$\frac{l}{d}$	N = 0·098	N = 0·075	N = 0·0646
20	1·13	1·17	1 19
25	1·20	1·26	1·30
30	1·29	1·38	1·44

The differences of $1+C_2$ for considerable differences of N are not very great. In any case N can be found by the method in the Appendix with little trouble.

In the case of columns fixed at one end and rounded or unfixed at the other, $2C_2$ must be substituted for C_2. If the column is rounded at both ends, $4C_2$ must be substituted for C.

KEY TO THE NOTATION.

The notation is built up on the principle of an index.

The significant words in any term are abbreviated down to their initial letter, and there are no exceptions.

Capital letters indicate moments, areas, volumes, total forces, total loads, ratios, and constants, etc.

Small letters indicate intensity of forces, intensity of loads, and intensity of stresses, lineal dimensions (lengths, distances, etc.), ratios, and constants, etc.

Dashed letters indicate ratios, such as $a_{\prime}$ $c_{\prime}$ $n_{\prime}$, etc., where the a, c, and n indicate the numerators in the respective ratios. The dash itself is mnemonic and is an abbreviation of that longer dash which indicates division or ratio.

Subscript letters are only used where one letter is insufficient ; and the subscript letters themselves are the initial or distinctive letters of the qualifying words.

Greek letters indicate ratios and constants. They are sparingly used and are subject to the "initial letter" principle.

The symbols below are arranged in alphabetical order for facility of reference.

Standard Notation.

IN PILLARS.

A = the effective *area* of the pillar (see definition on page 15).
A_E = *Area equivalent* to some given area or *area* of an *equivalent section* or equivalent area.
A_S = cross-sectional *area* of a vertical or diagonal *shear* member, or group of shear members, in the length p, where p = pitch of stirrups.
A_t = *Area* of *tensile* reinforcement (in square inches).
A_V = *Area* of *vertical* or longitudinal reinforcement in square inches.
a = *arm* of the resisting moment or lever *arm* (in inches).
$a_{\prime}$ = *arm* ratio $= a'd$ ∴ $a_{\prime}d=a$.
B = *Bending* moment of the external loads and reactions (in pound inches).
B_1 B_2 = *Bending* moments at consecutive cross-sections.
Generally b = *breadth*.

IN TEE BEAMS.

b = *breadth* of flange of beam (in inches).
b_r = *breadth* of *rib* of T beam (in inches).
C_1 C_2 C_3 = a series of *constants*.

IN BEAMS.

c = *compressive* stress on the compressed edge of the concrete (in lb. per sq. in.).

IN PILLARS.

c = working *compressive* stress on the concrete of the hooped core.

Standard Notation.

c_p=the working *compressive* stress on a *prism* of concrete (not hooped) or the working *compressive* stress of *plain* concrete.

c_u=*compressive* stress on concrete at the *underside* of the slab (in tee beams).

$c_{\prime}=c/t$ =the ratio of c to t.

IN CIRCULAR SECTIONS

Generally d=*diameter*.

IN RECTANGULAR SECTIONS.

Generally d=*depth*.

IN PILLARS.

d=the *diameter* of the hooped core in inches.

IN BEAMS.

d=effective *depth* of the beam (in inches).

d_c=*depth* or *distance* of the *centre* of compression from the compressed edge.

d_u=*deflection*.

d_s=total *depth* of the *slab* (in inches).

IN PILLARS.

d_v=*distance* between the centres of *vertical* bars measured perpendicular to the neutral axis.

E_c=*Elastic* modulus of *concrete* (in lb. per sq. in.).

E_s=*Elastic* modulus of *steel* (in lb. per sq. in.).

e=*eccentricity* of the load measured from the centre of the pillar (in inches).

IN BEAMS.

f=extreme *fibre* stress—*i.e.*, stress at the extreme "fibre" of any member under transverse load.

IN PILLARS.

f=a *form* factor or constant which will vary according to whether the hooping is curvilinear or rectilinear, etc.

I=*Inertia* moment of a member.

I_c=*Inertia* moment of *concrete* only.

I_s=*Inertia* moment of *steel* only.

I_{XX}=*Inertia* moment on axis XX when necessary.

I_{YY}=*Inertia* moment on axis YY when necessary.

l=*length* of a pillar or effective length of span of beam or slab.

m=*modular* ratio=E_s/E_c.

N=a *numerical* coefficient.

n=*neutral* axis depth—*i.e.*, depth of *neutral* axis from the extreme compressed edge (in inches).

$n_{\prime}=n/d$=the *neutral* axis ratio $\therefore\ n_{\prime}d=n$.

$N_2N_3N_4$=a series of numerical co-efficients.

P=total safe *pressure*.

IN PILLARS.

p=the *pitch* of the laterals in inches (*i.e.*, the axial spacing of the laterals).

IN SHEAR FORMULÆ.

p=*pitch* of distance apart (centre to centre) of the shear members or groups of shear members (measured horizontally).

π=*peripheral* ratio or the ratio of the circumference of a circle to its diameter.

R_c=*Compressive Resistance* moment=*Resistance* moment of the beam in terms of the *compressive* stress (in lb. in. units).

R_t=*Tensile Resistance* moment or Resistance moment in terms of the *tensile* stress (in lb. in.).

IN BEAMS.

$r=A_t/bd$=*ratio* of area of tensile reinforcement to the area *bd*.

IN PILLARS.

$r=V_h/V$=the *ratio* of volumes —*i.e.*, the ratio of the volume of *helical* or *horizontal* reinforcement to the volume of hooped core.

IN BEAMS.

S=the total *shear* in lb. at a vertical section.

S_m=the *section modulus*.

IN PILLARS.

s=*Spacing* factor or constant which will vary with the pitch of the laterals.

IN BEAMS.

s=intensity of the *shearing* stress on concrete in lb. per sq. in.

s_s=*shearing* stress on the *steel* (in units of force per unit of area).

$s_{\prime}=d_s/d$=the *slab* depth ratio.

T=Total *tension* in the steel (in lb.).

T_1T_2=Total *tensile* forces at consecutive cross-sections.

t=*tensile* stress on the steel (in lb. per sq. in.).

U=Total *ultimate* breaking load on any member. [Compare W=*Working* load.]

u=intensity of *ultimate* crushing resistance of plain concrete per unit of area or ultimate compressive stress on prisms of concrete not hooped.

IN PILLARS.

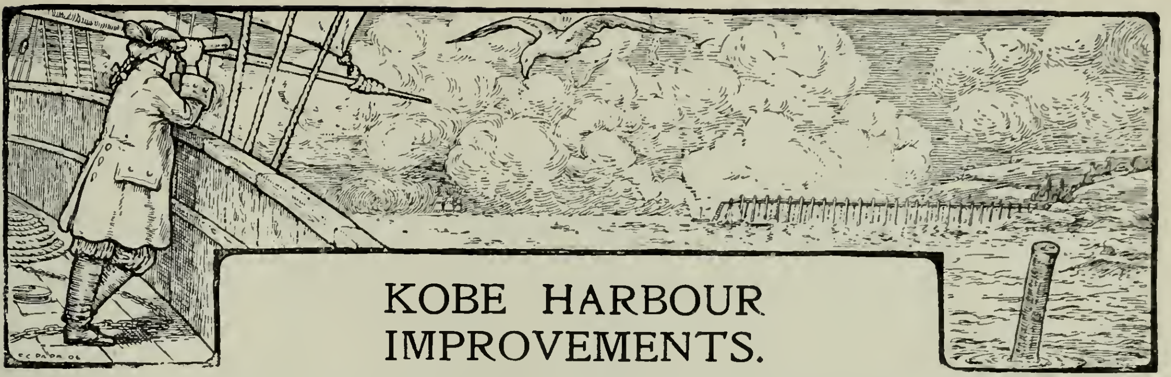
V=*Volume* of hooped core in cu. in.

V_h=*Volume* of *hooping* reinforcement in cu. in.

W=total *working* load or *weight* on any member.

W_F=the *working factor*=c_p/u= the reciprocal of the safety factor.

w=*weight* or load per unit of length of span.



KOBE HARBOUR IMPROVEMENTS.

It is with great pleasure that we give a description of the work in connection with the enlargement of Kobe Harbour and in particular of the reinforced concrete caissons for the foundations of the new quay walls.—ED.

KOBE is the second largest port in Japan, and is the most important shipping centre of the empire. In 1867 an Imperial Decree was issued ordering the port of Kobe to be opened to foreign trade, and in the following year the Eastern and Western Custom Houses were opened, four landing-places and three warehouses being also constructed. This was the origin of the accommodation for foreign trade in Kobe. Since that time additional landing-places, warehouses and sheds have been constructed year after year. In 1905 it was decided to construct two piers, to be completed within six years. These works, however, belonged to a temporary plan, and, seeing that they were inadequate to meet the requirements of the rapidly-increasing trade of the port, the scheme was modified; it being decided to reclaim the sea-front and fulfil the accommodations on shore, completing the whole in ten years, commencing with the year 1907.

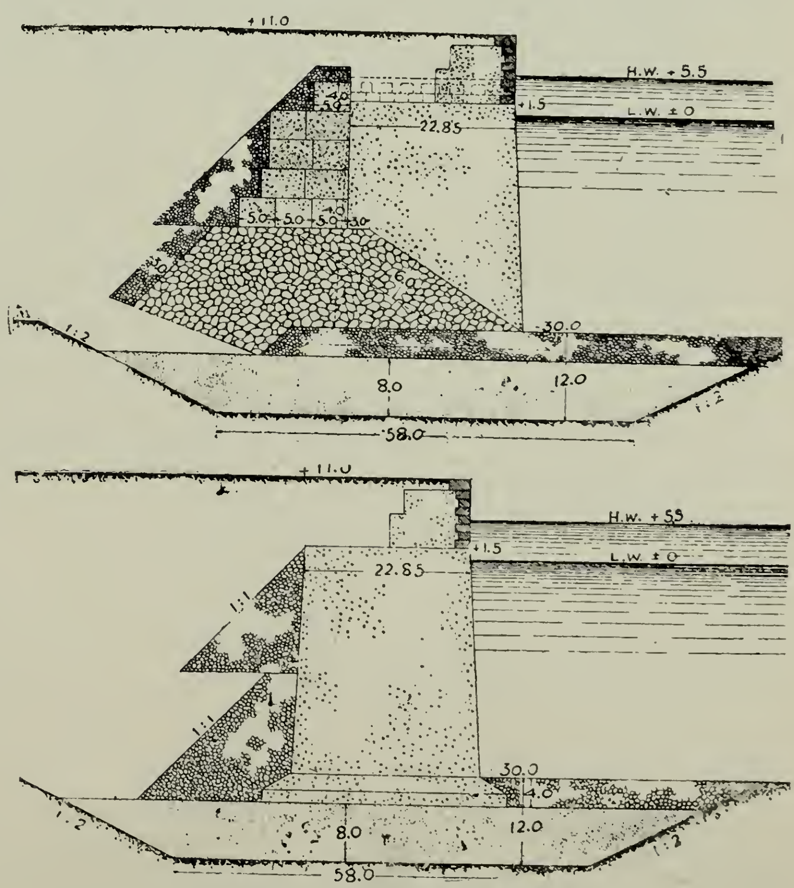


Fig. 1. Sections of Quay Wall. KOBE HARBOUR IMPROVEMENTS.

A sea-wall and quays are to be constructed, and foreshore-walls and landing-stages will be provided. The total area of the reclaimed ground will cover about 2,880,000 sq. ft. A line of breakwaters, 3,792 ft. long, forming a portion of the proposed breakwater for Kobe Harbour, will be constructed to protect the new accommodation. It will consist of rubble mound and concrete superstructure, 21 ft. in width, and 10 ft. above low-water level.

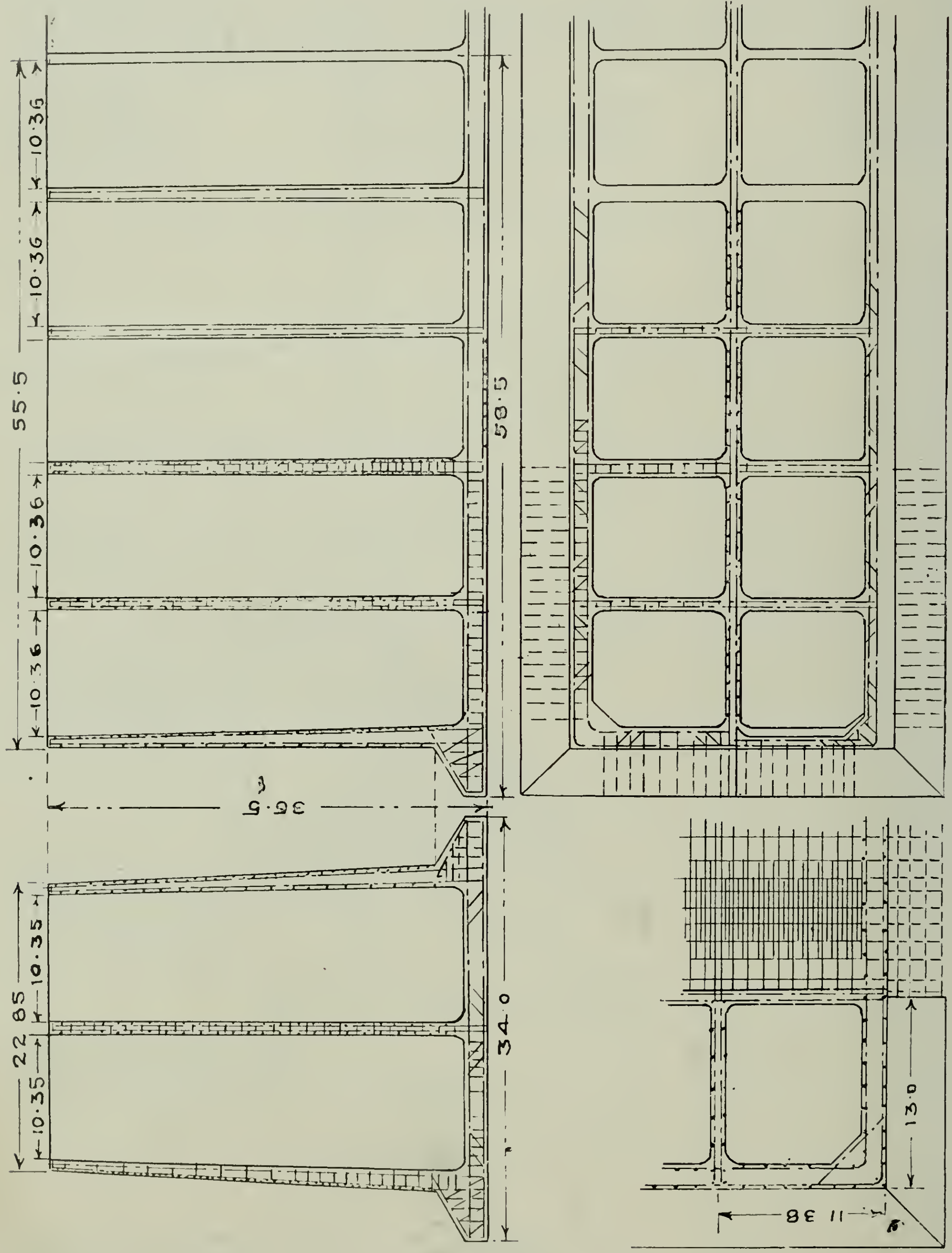


Fig. 2. Details of the Reinforced Concrete Caissons.
Kobe Harbour Improvements.

There are to be four piers, which, when completed, will give 8,412 ft. for loading purposes. They will be capable of accommodating nineteen steamers, representing a total tonnage of about 134,000 tons.

As the bottom of the harbour at Kobe has a stratum of soft mud to a depth of about 6 ft., great difficulties were anticipated in building the foundations of the new quay walls.

Reinforced concrete caissons are being adopted for the construction of these walls. The caissons are built on shore, and each one, on completion, is towed out by means of a floating depositing dock. Before depositing the caissons the nature of the soil at the bottom was tested to see whether it would bear the weight of the caisson at a proper depth. It was found that if about 6 ft. to 8 ft. of the surface soil were removed, the bed would be sufficiently strong to support the weight of the caisson and its superstructure. It was, therefore, decided to replace the surface soil by coarse sand.

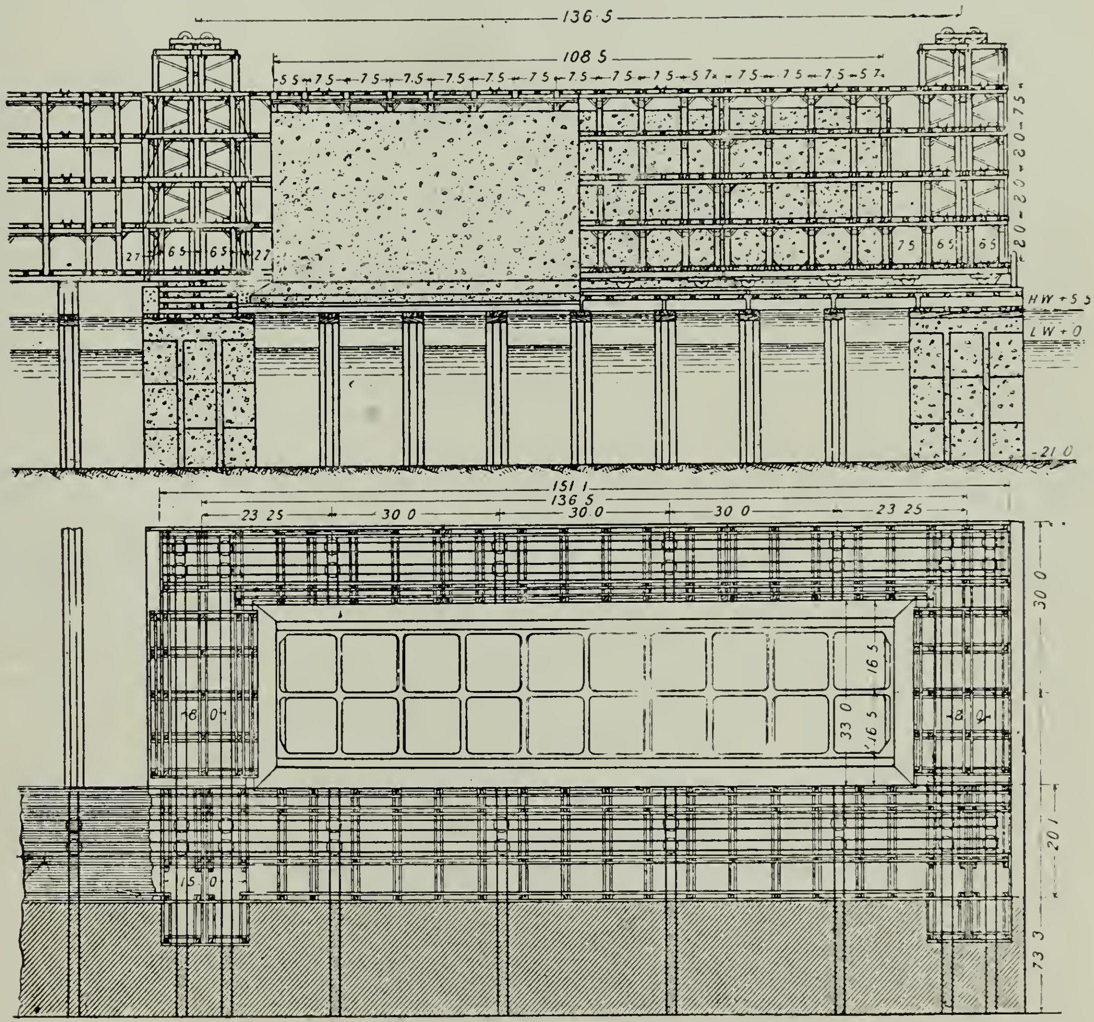


Fig. 3. Elevation and Plan of Caisson Building Site.
Kobe Harbour Improvements.

Each caisson building site is composed of seven rows of piles placed at 15 ft. centres, with their tops just above high-water level, and concrete end walls. The caissons are built on staging erected on top of these piles and on the concrete end walls. When ready the caissons are floated by means of a depositing dock, which was built by the Kawasaki Dockyard Co., Kobe, from the design of Messrs. Clark & Standfield, of Westminster.

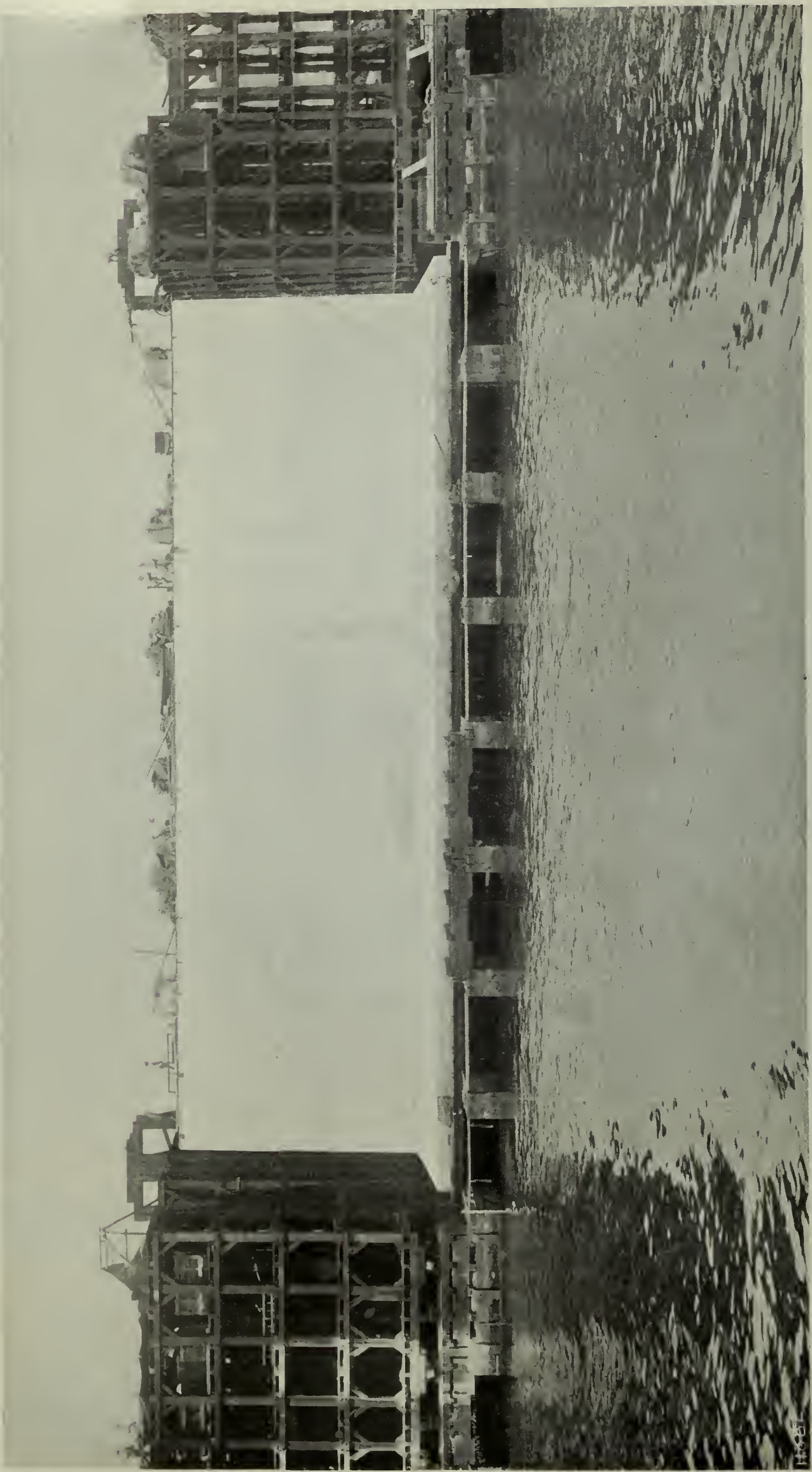


Fig. 4. Reinforced Concrete Caisson on Piers.
KOBE HARBOUR IMPROVEMENTS.

This depositing dock is 145 ft. in length, 137 ft. wide, and 51 ft. high, and in the centre there is a side wall 10 ft. wide. At the lower side of this wall eight pontoons are attached in the same manner as are the teeth of a comb. These pontoons are pushed into the spaces between piers to receive the caissons.

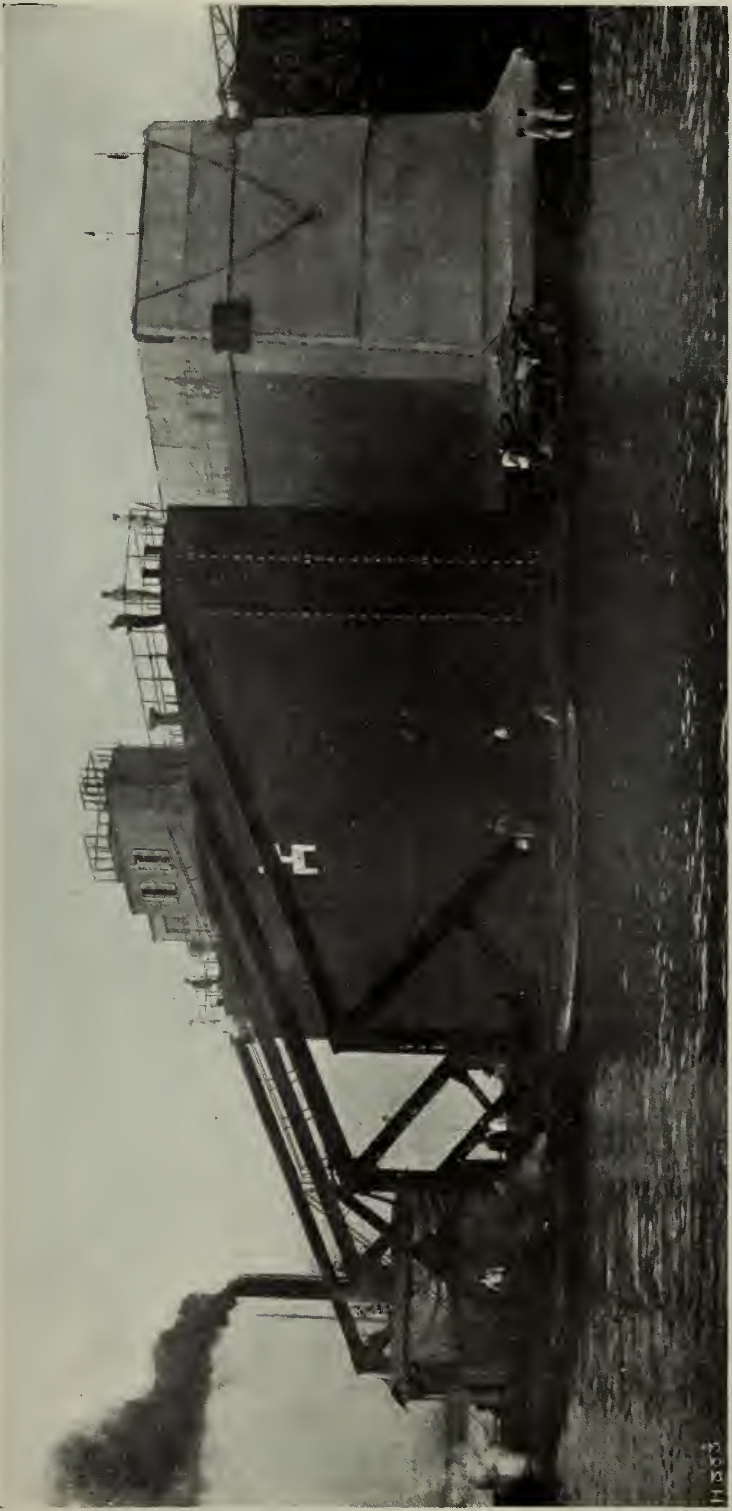
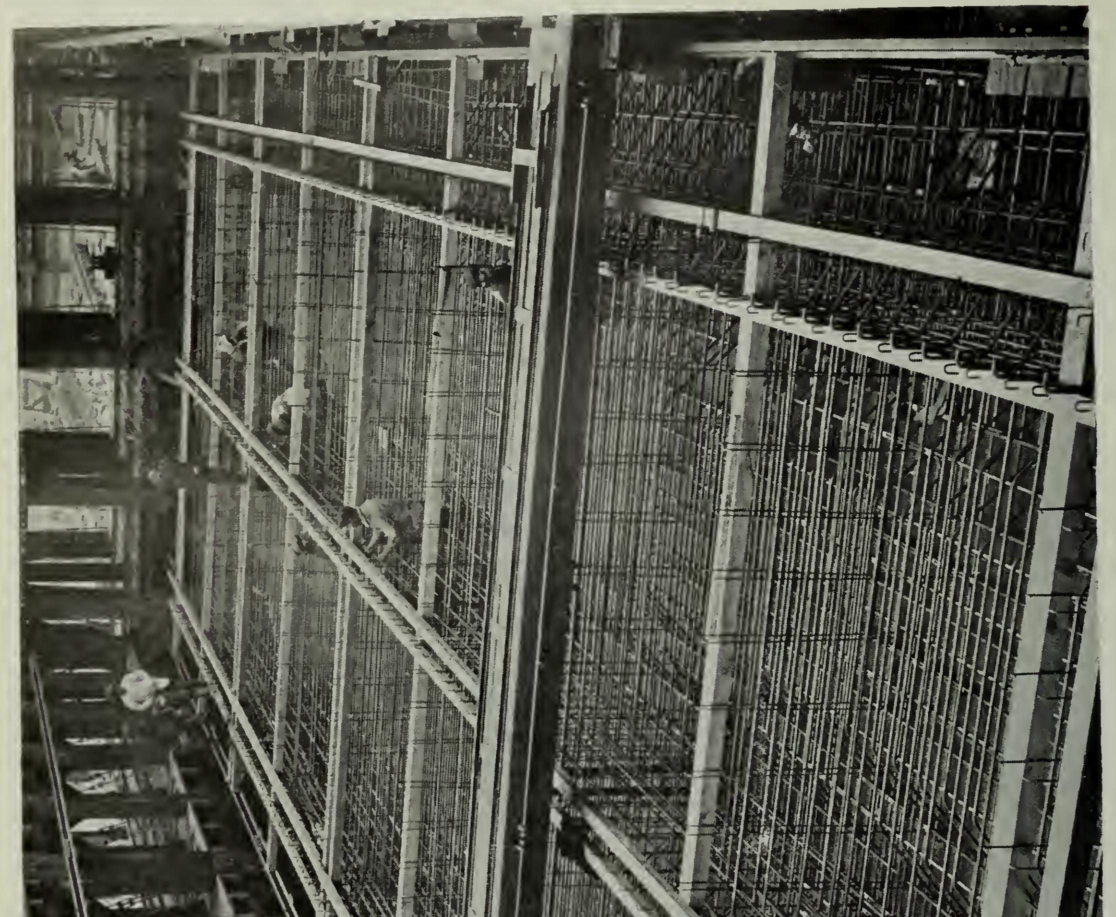


Fig. 5. Reinforced Concrete Caisson on the Depositing Dock.
Kobe Harbour Improvements

The caissons vary in size according to the depth of the quay, but the size mostly used is 119 ft. long, 35 ft. 6 in. high, and 23 ft. wide at the top and 34 ft. at the bottom. They are of cellular form, and of the shape shown in *Fig.* 2. They are built in wooden moulds, and are constructed of reinforced concrete, iron rods being used for the reinforcement. They vary in weight from 1,900 tons to 2,400 tons. They are divided by concrete walls so as to contain twenty cells, extending from the open top to within 2 ft. of the solid bottom. Both inside and outside walls of the caissons have a slope of 1/20, but the two ends are vertical. The thickness of side walls ranges from 1 ft. 6 in. to 8 in., while at the centre the longitudinal partition wall will be 9 in. in thickness.

Guide piles are placed so that each caisson drops into its proper position, and sufficient concrete ballast is then inserted to cause the caisson to sink.

When in position the caisson-top stands 1 ft. 6 in. above low water. When each caisson is deposited the four sections are closed immediately, and made watertight by affixing specially-made steel caps. These steel caps are furnished with two shafts of large diameter, and of a depth to raise the tops well above

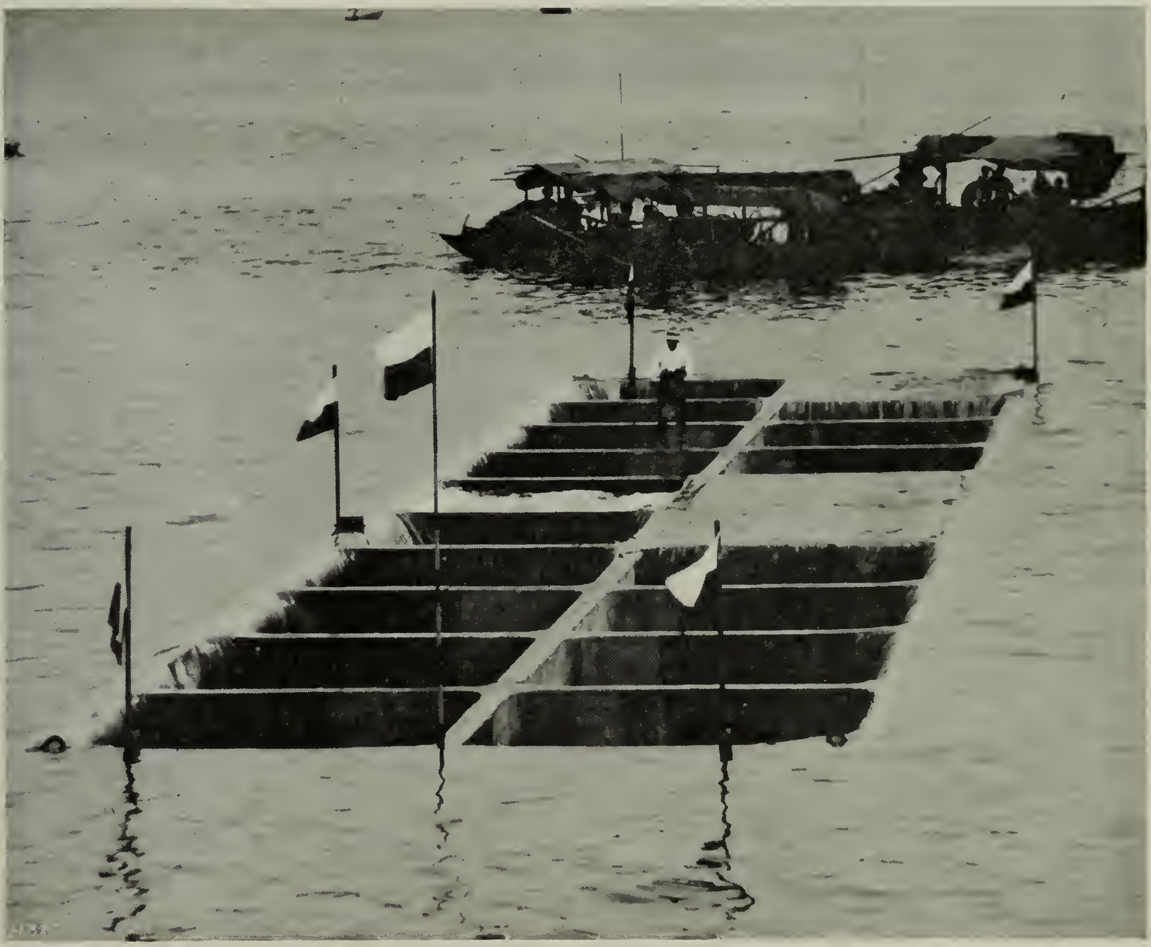


Reinforcement for Bottom of Caisson.
KOBE HARBOUR IMPROVEMENTS.

high water. The cells are pumped out, and are then filled with concrete and sand through the cylinder at the top of the cap. When the twenty sections are filled in turn, the main body of the caisson is completed, and forms the substructure of the quay walls.

The total number of caissons required will be eighty, of which fourteen have already been deposited. Very careful observation has been made to note the settlement of the deposited caissons, and up to the present the maximum is not more than 2 in.

The chief engineer of the Kobe Harbour Works is Mr. K. Yoshimata ; and we are indebted to him and to Mr. K. Monigaki, chief section engineer, for our photographs and particulars.



Caisson sunk into position.
Kobe Harbour Improvements.

RECENT BRITISH PATENTS RELATING TO CONCRETE.

We propose to present at intervals particulars of British Patents issued in connection with concrete and reinforced concrete. These particulars have been prepared for this Journal by Mr. A. W. Farnsworth, of Strand Chambers, Derby.—ED.

The Construction of Reinforced Concrete Floors.—*No.* 13,788/10. *J. E. Conzelman. Accepted January* 28/11.—This is another of the numerous attempts to reduce the cost of centering by the use of beams and slabs, which are placed in position ready made. The invention deals with a method of binding the slabs and beams together so that when completed the floor should be a monolithic whole. The beams are furnished with continuous brackets, (3) projecting along the sides to receive the flanges, (5) formed on the supported edges of the slabs. The tops of the beams are below the level of the upper faces of the slabs, but the space thus left, (6) is filled in with concrete on completion. Along the edges of the slabs at the joints are grooves, (7) and (8) which correspond in all cases. The slabs are laid in position with a slight space between them, (9) which is closed underneath by centering. Steel rods are placed in the grooves, and the upper ones pass over the beams, 13, thus giving continuity. Neat cement poured into the crack between the slabs holds the steel rods and forms a key.

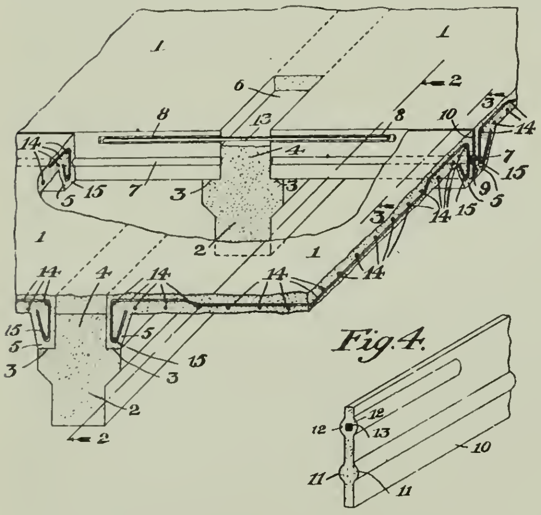


Fig. 4.

Another Floor System —*No.* 26,552/10. *F. Rings. Accepted June* 8/11.—This is another addition to the many designs of reinforced concrete floors already introduced. The floor is formed of small beams which can be made where most convenient, and afterwards transported to the building. The beams are of channel section, and steel reinforcement can, of course, be incorporated in them as considered necessary. The leading feature of the arrangement is the use of a double series of the beams to form a floor; one set is laid underneath with the flanges upwards, and another row rests on these with the flanges downwards. Projecting ribs along the sides of the lower beams serve to keep them slightly apart, thus forming pockets which can be afterwards grouted. The completed floor may be supported on walls or ordinary reinforced concrete beams, and with slight variation it can also be adapted to rest on steel girders. It is pointed out that the system is not limited to floors, but may be adopted in the construction of reinforced concrete walls.

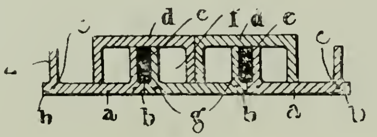


Fig. 1.

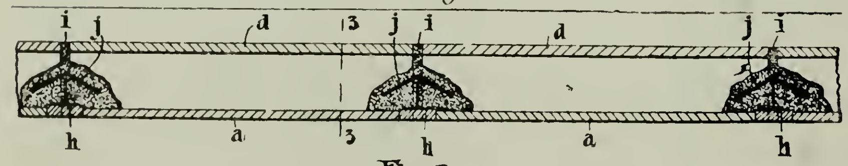
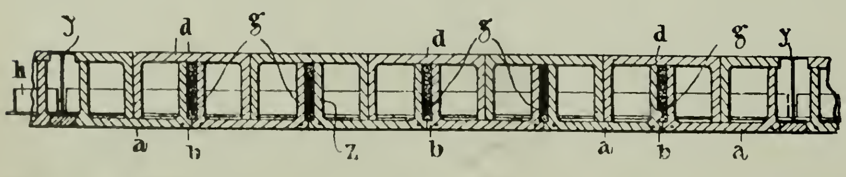


Fig. 2.



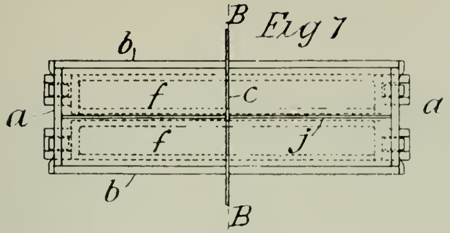


Fig 7

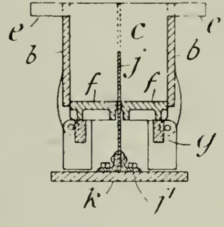
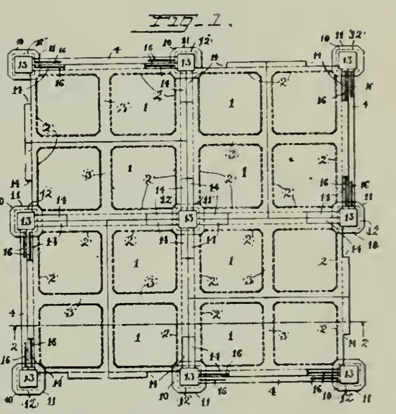


Fig 8.

An Improvement in Mould Boxes. — *No.* 848/10. *J. Faulder Burn. Accepted October* 6/10.—The object of the invention is to provide a practical means of dividing large moulding boxes used in the manufacture of concrete blocks, so that they may be utilised for turning out two or more smaller blocks. The arrangement refers more particularly to boxes with hinged sides and ends. The longitudinal division plate, *j*, may rest on the bottom of the box, or it may pass through it and rest on the bed plate of the moulding machine, *k*. Transverse divisions may be formed by other plates placed where desired, and at the points of intersection of the plates each is partly notched to receive the other. The ends of the plates may project in the form of lugs, *e*, through the sides of the box for convenience in lifting. When the divisions are not required the slots in the mould are closed by filling pieces.

Another System of Construction.—*No.* 13,786/10. *J. E. Conzelman. Accepted May* 4/11.—The principal feature of the invention consists in the abolition of separate secondary beams and the substitution of ribs actually formed on the slabs themselves, as shown in *Fig.* 2. At the joint between two slabs the ribs are so arranged that a projection, 5, on one slab rests in a corresponding shoulder in the next. The arrangement thus adopted permits the slabs to be laid close together without leaving any intervening spaces. Full particulars of the reinforcement details are supplied in the specification, but the other point of interest consists in the manner in which the column bases are dealt with. Reference to *Fig.* 1 will show that where these occur part of the upper slab projections are cut away, resulting in a cruciform recess (14). With a suitable disposition of the steelwork the column is built up in the centre of the recess, which is afterwards filled in with concrete.

Fig. 1.



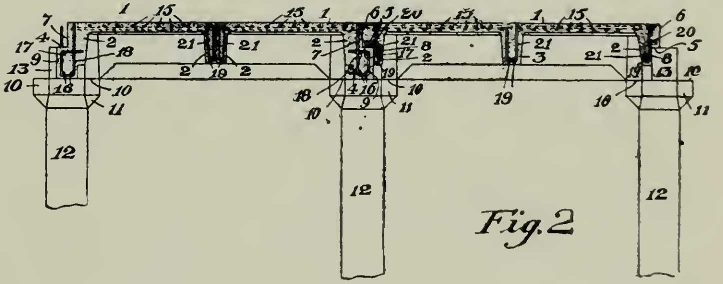


Fig.2

Large Span Roofs in Reinforced Concrete.—*No.* 6,789/10. *S. Rechniewski. Accepted March* 16/11.—In the specification the inventor describes a system of construction for wide-span roofs. The roof is formed in reinforced concrete, and supported at intervals by main beams of the same material which project above the roof and, consequently, do not affect the internal height of the building. The appearance of the beams in side elevation is somewhat similar to the well-known bow-string girder, but at the bottom they are open, and the sides slope inwards towards the top as shown in *Fig.* 3. A series of diaphragms between the two sides, *s*, resist any tendency to buckling. It is explained that glazing may be inserted in the sides of beams, thus providing roof-lantern lights or ventilation if desired.

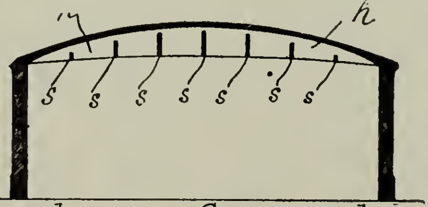


Fig. 2.

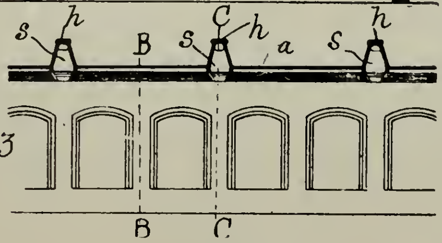
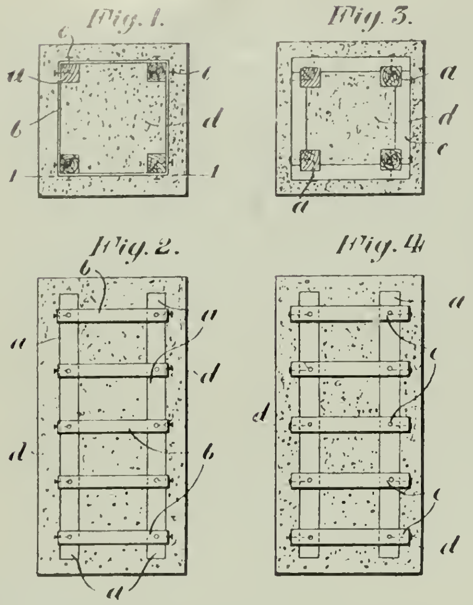
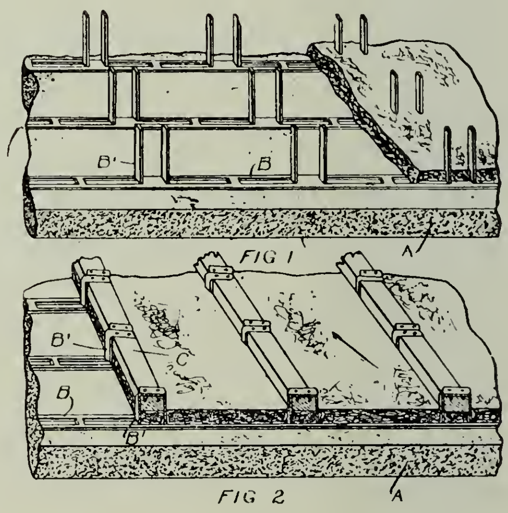


Fig 3

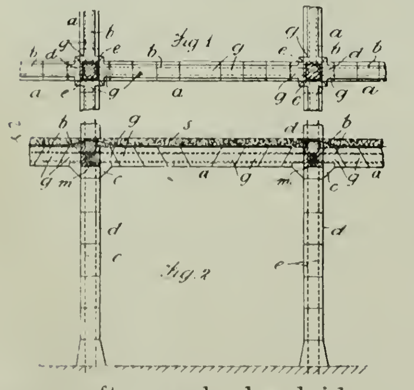


The Economical Construction of Concrete Piles and Posts.—*No.* 4,338/10. *G. O. Case. Accepted February* 2/11.—In this instance the inventor deals more particularly with the manufacture of concrete posts or piles which may be required to be made cheaply and quickly. In lieu of the usual metal reinforcement the use of a timber framing is suggested. A claim is also made for the combined use of wood and metal as shown in *Figs.* 1 and 2, where it will be seen that the wooden posts are held together by metallic bands, *b*. It is stated that it is found necessary to paint or treat wood with an appropriate preservative prior to embedding it in the concrete.

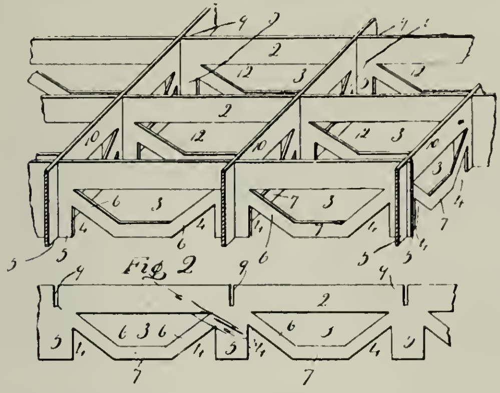
A New Device for Fixing Battens to Concrete.—*No.* 16,460/10. *Wright, Walmsley, and Belleau. Accepted December* 8/10.—The invention relates to an improved method of fixing battens between wood floors and concrete. Contrary to the usual practice, the battens are not fixed into the concrete, but are held in position by a series of metal clips, which form the feature of the invention. From *Fig.* 1 it will be seen that metal strips are placed in the concrete a short distance below its upper surface. The strips are cut so that each contains a series of tongues which correspond to the spacing of the battens. The tongues are bent upwards to receive the battens (*Fig.* 1), and then closed down on to them (*Fig.* 2). It is claimed that the invention avoids the difficulties encountered when the battens are held in position by the concrete, and that the risk of loosening, due to shrinkage of the timber, is considerably reduced.



Another System of Reinforcement.—*No.* 25,083/10. *F. D. Huntingdon. Accepted January* 12/11.—Several new suggestions are embodied in the inventor's description of his system. The columns are built up on any approved method, and furnished with caps to receive the main beams. The beams consist of a rolled steel joist core, *b*, whose ends rest on the column caps. The joist is encased in concrete saddle blocks, *g*, which, where necessary, are formed as skewbacks and keys. Grooves cut along the faces of the blocks at the joints permit the insertion of steel shear members which pass through openings made in the web of the joist. The spaces thus allowed between the blocks are afterwards grouted. The details of the attachment to the column are given in the specification. The floor slabs, which may afterwards be laid separately, are indicated at *s*.



Reinforcement for Concrete Paving.—*No.* 21,316/10. *J. H. McDonald. Accepted December* 22/10.—This is an improved system of interlocking steel bands intended to reinforce concrete paving. The inventor's aim has been to provide a satisfactory steel skeleton at a low cost. The framework consists of perforated metal strips intersecting at right angles, and slotted at the points of intersection so that they are securely interlocked and lie at the same level. Ample perforations, 3, permit the passage of the concrete during construction, thus ensuring thorough continuity. It is pointed out that the lower portions of the strips, 6, act as tension members and transmit the stresses to the vertical struts, 5, which in turn rest on a suitable foundation.



Adjustable Centering.—*No.* 1,410/11. *J. T. McNay. Accepted June* 1/11.—This is another of the attempts to reduce the cost of using new centering on each structure. In addition to the question of expense, time also becomes a factor for consideration when new falsework has to be constantly erected to suit various requirements. It is to deal with these objections that the inventor has introduced the adjustable centering shown in the illustration. It will be seen that the idea is to use a telescopic supporting beam furnished with its ends with adjustable steel clips which can be easily adapted to fasten on to the various supports. The beam consists of two outer portions, which can be erected at varying distances apart, and are furnished with steel straps on their inner ends. Fitting into a strap, and there secured by wedges, *d*, is a third timber which bridges the space between the outer ones, and completes the beam for supporting the shuttering. In order that a level top surface may be available, the gap at the centre of the beam is filled in with a locking piece, *e*. From *Fig.* 4 it

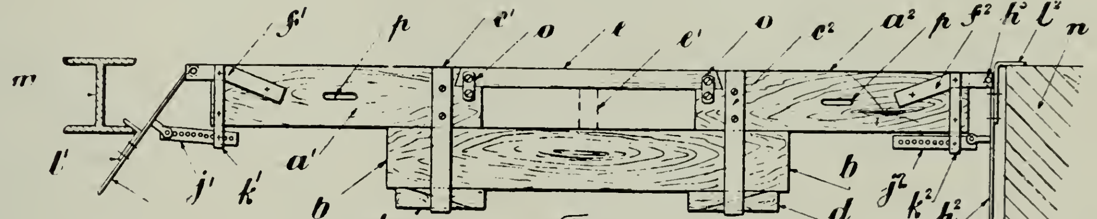


Fig. 1.

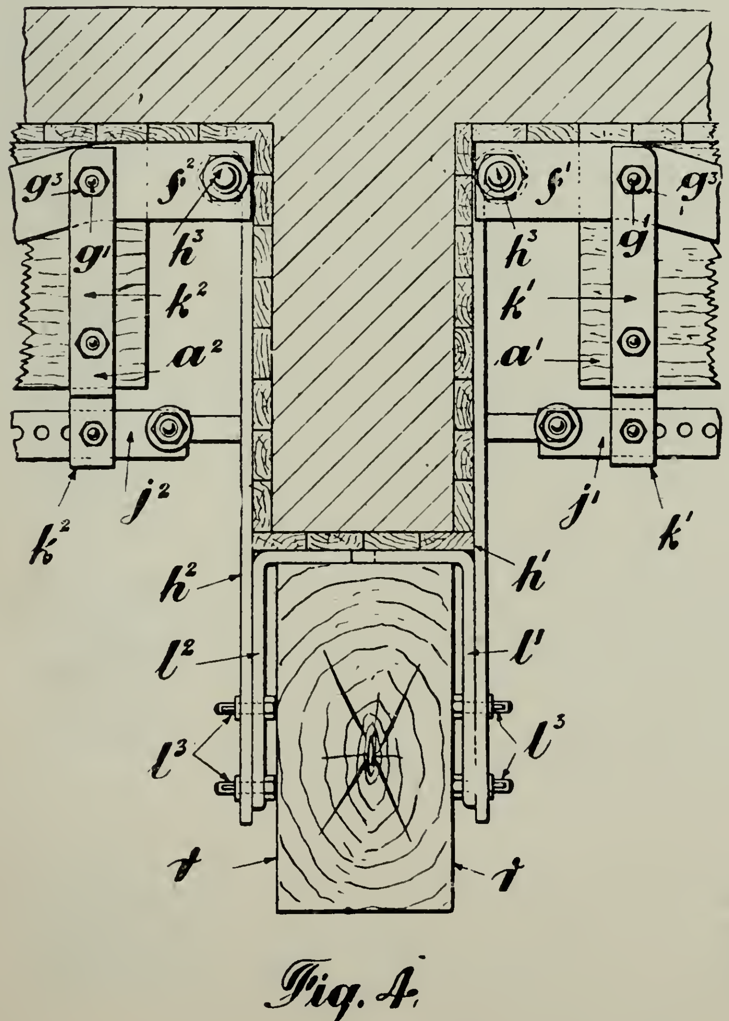
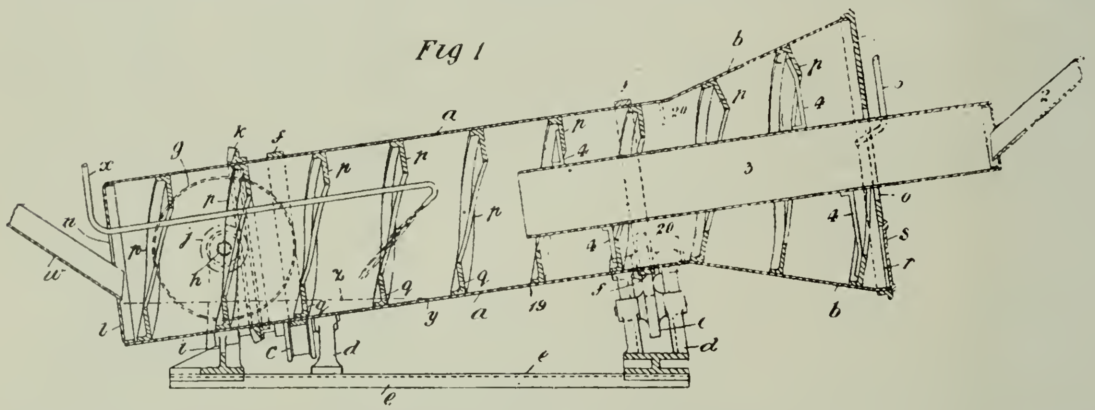


Fig. 4.

will be readily seen that the steel end fastenings can be easily adjusted to permit the formation of beams below the floor.

A New Concrete Mixer.—*No.* 16,015/10. *W. H. Baxter. Accepted May* 18/11.—The inventor points out that in previous mixers the various materials are first mixed together dry and then wet, but no washing or damping of the aggregate alone can be done except previously as a separate operation. He has therefore designed a new machine where all the operations can be carried out together. The revolving portion of the new mixer consists of an inclined cylinder which may be supported and rotated by any convenient means ; in the illustration it is shown mounted on rollers and driven by gearing. On the inside of the cylinder walls winds a continuous metal blade forming an internal screw which carries the material in the cylinder forward in spite of the inclination. The aggregate is fed into the machine at the lower end by means of the chute, *n*, and there meets the water entering the machine by the pipe, *x* ; the effect is to wash the stone as it moves forward. The dirty water can be allowed to escape through openings provided for the purpose in the casing. At the opposite end of the cylinder is another chute, 2, which directs sand and cement into the machine by the internal tube, 3. These materials fall on to the washed stone, and the whole mass is then thoroughly mixed together during its passage to the large end of the cylinder. The process is at first dry, but as the material moves towards the end, the necessary amount of water is supplied through another pipe, 5. A special type of outlet door is adopted, which, together with other details or modifications, is fully described in the specification.

Fig 1



A New Reinforcement for Piles.—*No.* 22,618/10. *E. Mohun. Accepted April* 20/11.—The inventor has endeavoured to secure a more thorough distribution of the steel reinforcement than he considers possible when using the ordinary rods. He has therefore adopted light steel angle bars for the corner verticals of the skeleton, and these are wired to small cast-iron frames, 10, at intervals of about 8 ft. The frames are rectangular, with two intersecting cross webs which meet at the centre in a small boss ; at this point a hole is made for the hydraulic jet pipe leading to the extremity of the shoe. The framework is then enclosed with expanded metal which is wired to it. The pile shoe is of sheet metal rigidly secured to the bottom cross frame. It is stated that the pile may be conveniently moulded horizontally, and the inventor also points out that a good outer layer of concrete is obtained which cannot easily break away from the steelwork.

Fig.1

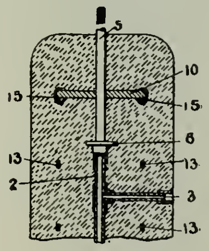


Fig.2.

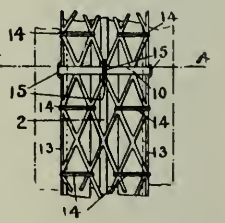
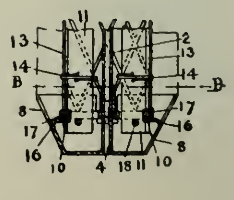
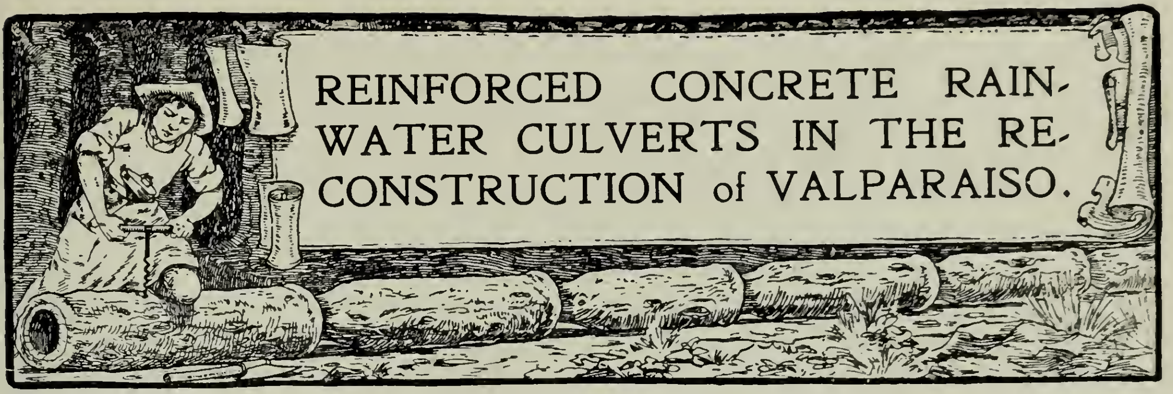


Fig.3.





REINFORCED CONCRETE RAINWATER CULVERTS IN THE RECONSTRUCTION of VALPARAISO.

By T. P. CLIFF, Northwich.

The following account of the work of laying the reinforced concrete rainwater culverts in Valparaiso after the earthquake of 1906 is exceedingly interesting, and merits the attention of our readers.—ED.

After the town of Valparaiso had been destroyed by the earthquake of 1906 the Chilian Government decided to rebuild it according to modern conditions, and generally to replan it by making new and wider well-paved streets, with public underground conveniences and avenues planted with trees. This meant a great deal of work, and owing to the fact that there was no exact plan of the town the lines of the streets had to be defined as well as possible from the ruins.

The work of reconstruction was a tremendous undertaking, and, on account of the widening of the old streets and the opening out of new streets and avenues, it was necessary to relay the whole of the services of the town—viz., sewerage, water, gas, electric cables, telephones, and tramways. The peculiar situation of Valparaiso, at the foot of the Andes mountains, demands an extensive system of culverts to take away the rainwater after a heavy fall. In previous years the bursting of culverts and overflows was quite common, and caused considerable damage in making the streets impassable, so it was decided to take advantage of the opportunity which now presented itself for revising the whole system.

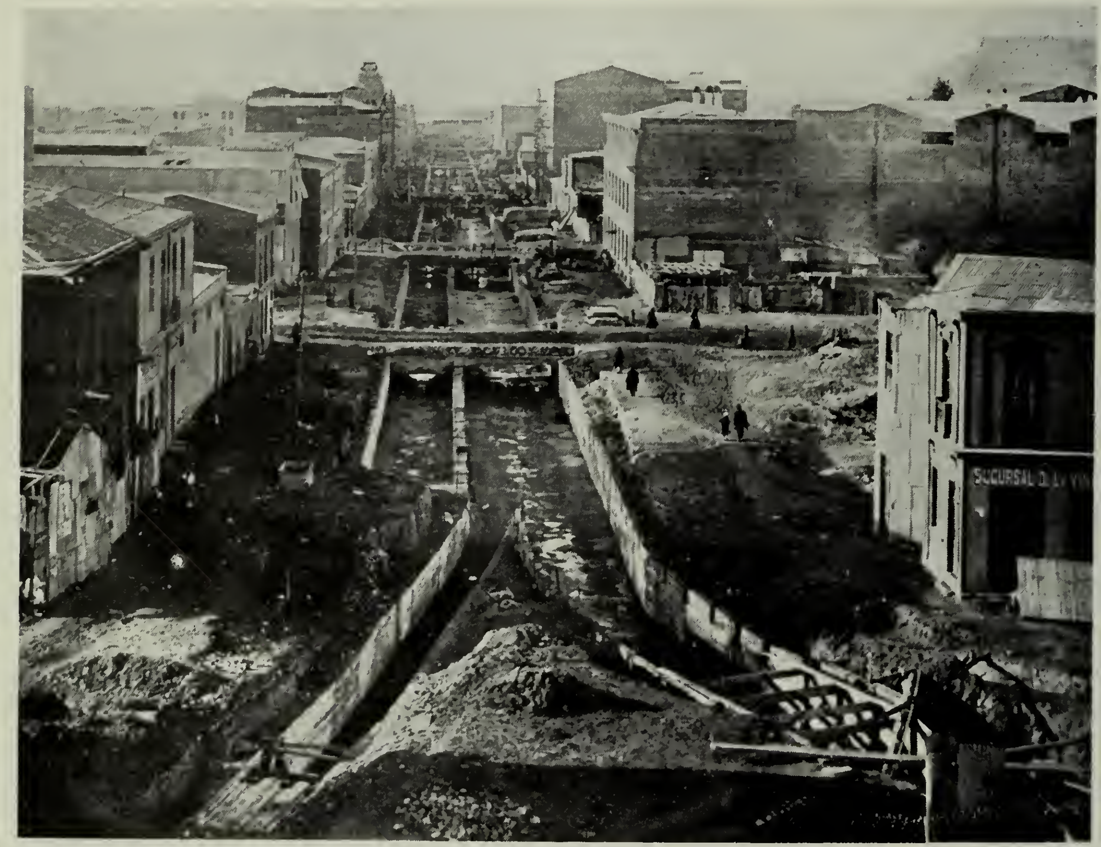
The rainwater culverts were considered the most important part of the works of reconstruction, and they were designed to take away to the sea the rainwater which accumulates from the mountains after a heavy rainfall, as well as the enormous quantities of sand, refuse, etc., etc., which formerly had been deposited in the valleys during the dry season. Consequently it was arranged to rebuild the culverts under the streets from the foot of the mountains to the sea, provision being made for a culvert in almost every street.

The dimensions of the culverts were based on past experience, but all are of sufficient height and width to allow of a man entering with a barrow, and, although manholes for cleaning purposes were placed at every street corner, allowance was made for negligence in cleaning.

The culvert with which this article deals is the largest of the system. It has an overall inside width of 10·60 metres, and is 2 metres high, but it is divided by a division wall 1·40 metres high by 0·60 metre thick, making two culverts 6 metres and 4 metres wide respectively. Columns at 2·40 metres centre to centre are continued above the division wall to carry arched ribs, which support the cover, and thus it will be seen that the two culverts have communication with each other between the columns of the division wall. The smaller culvert is used as an auxiliary during cleaning operations, it being understood that only on very rare occasions will the water rise above the level of 1·40 metres.

The falls of the culverts were arranged as nearly as possible parallel with the street surfaces, but in one or two cases difficulties presented themselves which were overcome on the work. The main outlet has a fall of 5 : 1,000, so that the culvert enters the sea at the level of average high water.

The excavations were all done by small contracts arranged with separate gangs of men, and they were afterwards measured, levelled, and paid for by the cubic metre. The trenches averaged 13 metres wide and 3·50 metres deep, and the excavated material was carted away and used in the filling up of various streets to their new level, sufficient being left for the covering over of the new culvert. A part of the excavation was in sand, which was conserved and used in the construction works. Further, a lot of old foundations were encountered, and much of the stone from them was used for the new work, while the remainder was crushed for use in the concrete. Thus considerable economies were effected.



General view without cover.

Reinforced Concrete Rainwater Culverts in the Reconstruction of Valparaiso.

When the working levels had been placed in the trenches wood templates curved to the inverts of the two culverts were centred, levelled, and fixed in position, and the reinforced concrete work was started. The outside walls were constructed by means of boxes made specially, with the required batter, to join at the columns, and the inside boxes were centred and supported by wooden horses. Throughout the base of the outside and centre walls a strip of No. 13, 6-in. diamond mesh expanded steel was used as reinforcement, and at every 2·40 metres four $\frac{3}{4}$-in. dia. bars were used vertically to reinforce the columns, their ends being splayed at 90° to distribute over a greater area the weight from the beams carrying the cover and roadway. The outside walls were reinforced with No. 10 3-in. diamond mesh expanded steel, placed in the front face from centre to centre of the columns, the sheets being slightly bent at their ends to enter between the vertical bars into the heart of the columns. The outside walls are 0·20 metre in thickness at the top and 0·30 metre at the bottom, and the centre wall is 0·60 metre thick and 1·40 metres high, with columns 0·35 metre by 0·50 metre, every 2·40 metres, centre to centre.

The reinforced concrete cover was designed to carry a steam-roller of 20 tons, together with ordinary street traffic. It consisted of transverse concrete beams reinforced with Kahn bars, the beams being placed 2·40 metres centre to centre ; longitudinal concrete arches, reinforced with plain round bars, spanning from beam to beam and on to the columns over the centre wall, to form openings for the water to pass from the larger to the smaller culvert ; and a concrete cover, reinforced with No. 62, 3-in. diamond mesh expanded steel.

For the 6-metres culvert the beams are 0·60 metre deep, including the cover, and 0·33 metre wide ; in the 4-metres culvert the beams are 0·50 metre deep, including the cover, and 0·30 metre wide, and the cover is 0·15 metre thick.

View shewing expanded steel being embedded in concrete.

Reinforced Concrete Rainwater Culverts in the Reconstruction of Valparaiso.

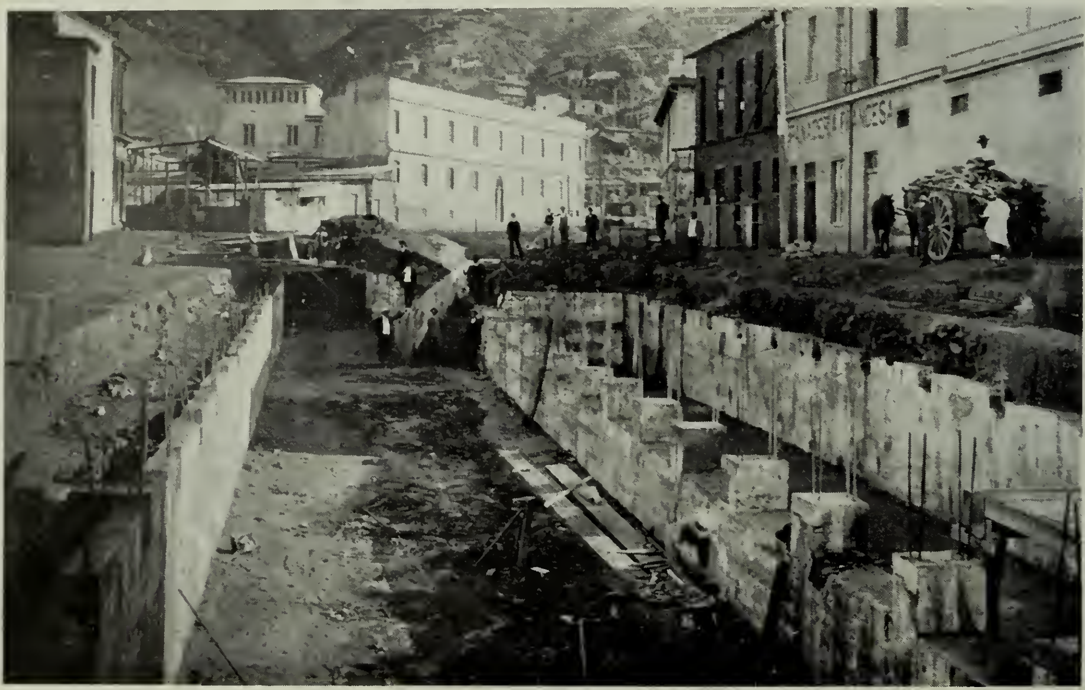
In the concrete beams were placed three Kahn bars, giving an area of 8 sq. in. and 6 sq. in. respectively. The middle bar in each case was curved up at its ends to take shearing stresses, and all the wings of the bars were bent up at an angle of 45°. The bars were fixed temporarily in position, and very fine concrete was poured and rammed over them until they were completely buried. After the beam boxes had been filled with concrete the cover slab was commenced. A continuous layer of No. 62, 3-in. diamond mesh expanded steel, as bottom reinforcement, was laid in position on the cover falsework, the sheets butting at their ends along the centre over the transverse beams. Then concrete 0·15 metre thick was laid, with a tension strip of expanded steel 0·80 metre long, as top reinforcement, placed near the top of the concrete slab over the beams. Care was taken to get the expanded steel completely embedded about ½ in. from the bottom and top faces of the concrete, and thus a slab cover of continuous formation was obtained.

The manhole openings are reinforced with plain round bars, the manhole covers were specially designed and are expanded steel-concrete slabs fitted in a cast-iron frame, and having keyway holes to allow of their being lifted in and out of position.

The concrete was mixed principally by a portable Smith mixer, self-contained, $\frac{1}{3}$ cubic yard type.

For the temporary centering Oregon pine was used, the timber being planed on the inside face for the beams, left rough for the cover, and chamfered at all angles to prevent sharp arrises on the concrete; the falsework was made in framed pieces to allow of quickness in erection, and of its being used over and over again. The main centering was left in position for two weeks, and the bottoms of the beam boxes for three weeks.

There were many difficulties encountered during the execution of the work and each had to be overcome with as little hindrance as possible—*e.g.*, breakages of sewer pipes, water pipes, gas pipes, cutting of electric cables, etc. Particular trouble was experienced in constructing the culvert under the tram lines—this was accomplished by spanning the culvert with girders and supporting the tram lines with 12 in. by 12 in. timbers and afterwards joining up the culvert, the traffic not being hindered for a minute.



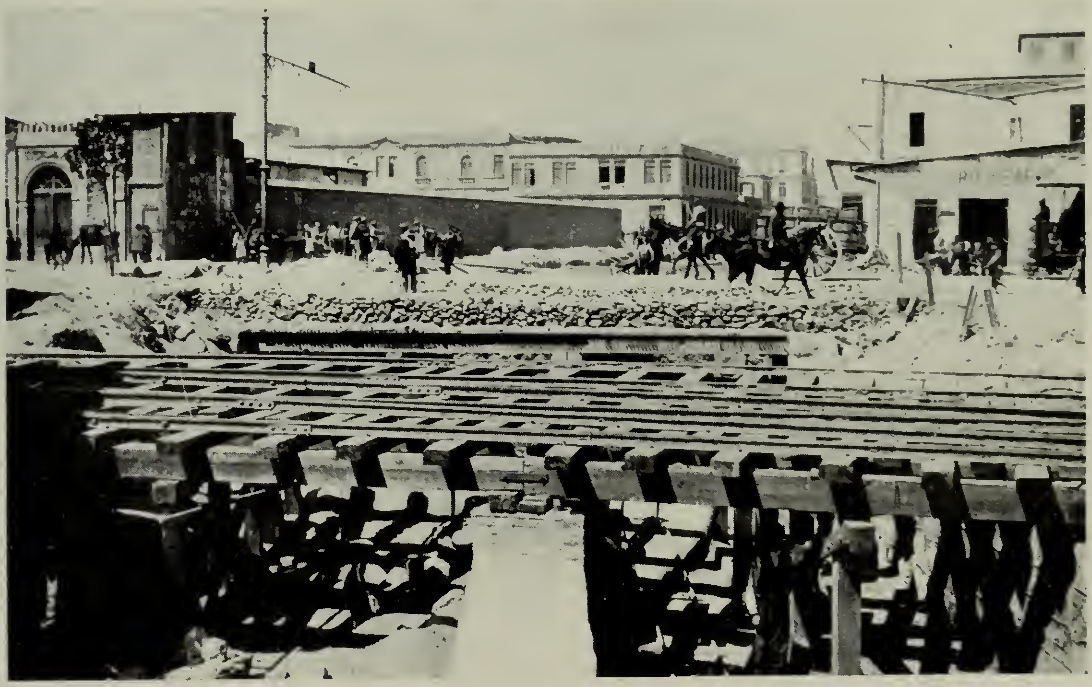
View shewing divisional wall with columns.

Reinforced Concrete Rainwater Culverts in the Reconstruction of Valparaiso.

The most difficult and important part of the constructional work was the building of the culvert underneath the railway lines in the station yard, there being 23 lines to pass under, and with the enormous traffic and shunting operations continually in progress it will readily be imagined that the work was greatly hindered. The execution of this portion of the work was carried out in the following manner: 12 in. by 12 in. timber beams of sufficient length to span over the whole culvert were placed beneath the sleepers under each railway line, when excavations were commenced and timber horses placed under the beams at sufficient depth and width to obviate interference with the building of the foundations and walls. When the beams were supported in position excavations were begun near the sea and the earth was taken out by Decauville cars and deposited in the sea, it being necessary to erect a temporary tipping stage for the purpose. The cars were drawn up the inclined plane by means of a wire rope and hauling engine with a loose pulley attached to the stage, by which arrangement work was greatly facilitated and carried out in a rapid manner. In the meantime the foundations were continued, and the side and centre walls, being built of masonry, were ready to receive the lattice braced bridges for each line, the bridges being rolled into position and gradually packed up on the abutments. Between each batch of railway lines there are roadways constructed of reinforced concrete similar to those previously described.

The outfall in the sea was next considered, and it was constructed by driving old railway lines into the foreshore, with the tops left protruding to allow of their entering the foundation and the side walls ; the middle wall was dispensed with and the outside walls were formed into a bellmouth, which gradually runs away to water level, the whole being tied together by expanded steel.

The expanded steel, of which large quantities were used, was supplied by the Expanded Metal Co., Ltd., of London and West Hartlepool, England.

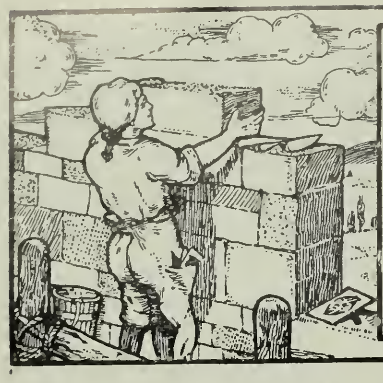


View shewing culverts under railway lines.

REINFORCED CONCRETE RAINWATER CULVERTS IN THE RECONSTRUCTION OF VALPARAISO.

The Kahn bars were supplied by the Trussed Concrete Steel Co., of Detroit, Mich., U.S.A.

The whole of the works of the reconstruction of Valparaiso were placed in the hands of Senor Enrique Budge, M.Inst.C.E., and the author, Mr. T. P. Cliff, acted directly under him in the designing and carrying out of all the culverts, which work extended over a period of three years.



CONCRETE ENGINEERING (PRACTICAL).

By A. C. DAVIS, F.C.S., Assoc.Inst.C.E.

A course of lectures dealing with Portland Cement and Concrete Engineering was recently given by Mr. A. C. Davis at the University of Cambridge. In our June issue we gave the text of the lecture on "The Testing of Portland Cement," and in a future number we shall publish the concluding discourses on the theoretical side of concrete engineering.—ED.

The application of Portland cement in general construction covers so wide a sphere of usefulness that each year finds it successfully employed in some new work, and numerous evidences of this point to the great strides which have been made during recent years in the science of the manufacture of this invaluable product. Bridges, breakwaters, docks, canals, dams, reservoirs, cement concrete streets and footpaths, with their remarkable neatness and evenness, together with partitions, roofing tiles, paving slabs, building blocks, boats, rafts, barges and caissons, and to-day entire buildings and pressure pipe lines erected in reinforced concrete, represent a few of the important works constructed with Portland cement. These illustrations mark but the beginning of the era of cement in the field of engineering and architecture.

Concrete consists of the combination of two materials—the aggregate, or filling material, consisting of broken stone or sand, and the matrix or matrice, the binding material, for which Portland cement is almost universally used.

AGGREGATES.

The nature of the aggregate is generally determined by the locality of the site upon which the concrete is made.

The aggregates which can be used from the point of view of strength in the resulting concrete are named in the following list in order of merit. They are granite, gravel, marble, limestone, slag, sandstone, slate, shale, and cinders. Granite, being first on the list, is the best of the aggregates, cinders, being last, are the worst. Since the setting of Portland cement is a chemical process, aggregates should be free from any injurious matter which will enter into combination with the cement in setting.

Sulphur is extremely injurious, and samples of slag—the residue from blast furnaces—coal, or indeed any material should be rejected if they contain any appreciable quantity of sulphur.

Clay and vegetable matter should also be avoided. If the aggregate contains more than 2 or 3 per cent. of clay, or, indeed, any clay in the form of lumps, it should be rejected, or should be washed before using.

The size of the aggregate should vary from pieces of the largest size down to fine sand. Large masses of concrete may contain stone from the size of 3-in. cubes downwards. For smaller sections, such as a floor, slab, or beam, the maximum size should not exceed one-fourth of the thickness of the finished product. For such purposes it is usual to use stone varying from 1 in. or from ¾ in. down to fine sand.

The theory of mixing concrete is that no voids or air spaces should be left between the particles of stone, sand, and cement. The finer grades (and sand) should be sufficient to fill the voids between the coarser grains, and the cement should fill the voids in the sand.

For practical convenience the aggregates in concrete making are divided into two sections—the coarse material or stone, and the fine material or sand. The coarse material includes all sizes down to ⅜ in. The sand includes everything from ¼ in. down to the finest flour.

The quantities of stone, sand, and cement which must be used may be found by testing to ascertain the percentage of voids.

Coarse aggregates have fewer voids than fine aggregates, therefore as much coarse stone should be used as possible.

Similarly, coarse sand has fewer voids than fine sand, and if the sand is coarse, a smaller quantity of cement will be required to produce the same strength than with fine sand.

A ready method of testing to find the voids in an aggregate, is to take any convenient receptacle, say, a bucket, and ascertain the weight of sufficient water to fill it. It is then emptied and filled with the aggregate to be tested. The bucket and aggregate are then balanced upon the scales—its weight is immaterial—but the weight of water which can be added without overflowing from the bucket should be carefully noted. This weight, divided by the weight of water which will fill the bucket without the aggregate, is the proportion of voids.

PREPARATION OF THE CONCRETE.

The proportions for a mix of concrete, given, for instance, 1 part of cement to 2 parts of sand and 4 parts of stone or gravel, are written 1 : 2 : 4, and this means that 1 cu. ft. of packed cement is to be mixed with 2 cu. ft. of sand and with 4 cu. ft. of loose stone.

For ordinary work twice as much coarse aggregate should be used—that is, gravel or stone, as fine aggregate (sand).

If, when placing concrete with the proportions specified, a wall may show many voids or pockets of stone, a little more sand should be used and a little less stone. If, on the other hand, when placing concrete in position, a quantity of fine mortar rises to the top, less sand and more stone should be employed in the next batch of work.

In calculating the amount of each of the materials to be used for any piece of work, one must avoid the mistake so often made that one barrel of cement, two barrels of sand, and four barrels of stone will make a capacity of seven barrels of concrete. The sand and cement fill the voids between the stones, and, therefore, the total quantity of concrete in this case will be slightly in excess of the original quantity of stone only.

The proportions of matrice and fine and coarse aggregates in concrete are generally :

(*a*) In a *rich mixture* for columns and other structural parts subjected to high stresses or requiring exceptional water-tightness, 1 : 1½ : 3.

(*b*) In a *standard mixture* for reinforced floors, beams, and columns, for arches, for reinforced engine or machine foundations subject to vibrations, for tanks, sewers, conduits, and other watertight work, the proportions should be 1 : 2 : 4.

(*c*) A *medium mixture* for ordinary machine foundations, retaining walls, abutments, piers, thin foundation walls, building walls, ordinary floors, sidewalks, and sewers with heavy walls : proportions, 1 : 2½ : 5.

(*d*) A *lean mixture* for unimportant work in masses, for heavy walls, for large foundations supporting a stationary load, and for backing for stone masonry : proportions, 1 : 3 : 6.

Care should be taken that clean water is used for mixing the concrete. Water from ponds and streams may contain clay, organic matter, chemical waste, or other injurious ingredients in solution or suspension, and should therefore be avoided.

The cement and aggregate should be thoroughly mixed together in a dry state before the water is added. Too much or too little water should be avoided. Theoretically, just sufficient water to enter into chemical combination with the cement should be used, but practically sufficient water is required to allow the materials to slide easily over each other so that they can be packed into place in making the concrete.

Thorough mixing is essential, and machine mixers are to be preferred. They are more efficient, and the resulting concrete is sometimes 25 per cent. stronger through being efficiently mixed.

Retempering mortar or concrete—*i.e.*, remixing with water after it has partially set, should not be allowed.

Concrete, after the addition of water to the mix, should be handled rapidly (and in as small masses as is practicable) from the place of mixing to the place of final deposit, and under no circumstances should concrete be used that has partially set before final placing. A slow-setting cement should therefore be used when a long time is likely to occur between moving and final placing.

The concrete must be deposited in such a manner as will permit the most thorough compacting, such as can be obtained by working with a straight shovel or slicing tool kept moving up and down until all the ingredients have settled in their proper place by gravity, and the surplus water has been forced to the surface.

Some of the common causes of failure in the making of concrete, then, are as follows :

Firstly, the use of too much water during mixing, or water carelessly applied, or an insufficient quantity of water.

Secondly, the use of an insufficiently graded aggregate, and one containing only very coarse material, or one with too much sand or loam.

Thirdly, the incomplete incorporation of the aggregate with the cement, or allowing the concrete to stand until the setting action has commenced, and then regauging before use.

Fourthly, the use of unsuitable aggregates.

Fifthly, the rendering of cement work on dry foundations and without thoroughly saturating the surface with water.

Sixthly, the use of a dirty aggregate or water containing earthy matter, clay, or loam.

Or, again, the repeated " floating " or trowelling of cement surfaces makes unsatisfactory concrete.

CENTERING.

The timber *centering* work is now a problem to be dealt with, and in this respect the supporting forms must be of such dimensions and so constructed as to remain rigid and unyielding during the laying and ramming of the concrete. It must be so arranged as to permit of easing and removal without jarring the concrete, whilst it is what is termed " green "—*i.e.*, immature.

The primary object in designing centering should be ease in removal and facility for quick erection, a point which is of the utmost importance where there is much repetition on a contract. A careful study of the most suitable arrangement of the centering is time well spent. It should never be forgotten that the cost of centering is nearly always a large percentage of the total cost of the structure, and economy on this item will frequently mean an appreciable sum of money. Where it is possible, and the smaller spans permit, it is frequently desirable to arrange for the floor slab centering to be carried on the secondary beam troughing, and for this troughing to be carried in turn on the column boxing. With large beams of considerable span this, generally speaking, will not be possible, and arrangements must be made for the beam troughing to be carried by struts. The beam troughing should be so designed that the under or bottom board may remain in position after the side boards and the floor centering have been removed. All struts under beams, etc., should be wedged from below at the floor level, and not at the top of the struts. The ends of the beams should be haunched on to the supports where this is possible, especially in continuous beams. Thick timber is better than thin, as it lasts much longer, stands rough handling better, and is more economical in the end. In the construction of reinforced concrete walls it is generally advisable to fix the outer shuttering first, then place the steel in position, and add the inner shuttering as the work proceeds. To keep the inner and outer faces of the shuttering for walls the proper distance apart, perforated wood plugs or concrete separators are used, a bolt being driven through the plugs, keeping the shuttering tight and rigid. After the shuttering is removed, the holes left in the concrete are, of course, filled. When all the centering is fixed and coated with oil or soap, and the steel placed in position, it is advisable to thoroughly flush the centering and moulds with water before any concreting is commenced.

PLACING CONCRETE.

After preparing the materials and arranging for the constructional work to proceed, the thickness of loose concrete that is to be rammed should not exceed 3 in., especially in the vicinity of any reinforcing metal. Special care is to be taken to ensure perfect contact between the concrete and the reinforcement, and that the ramming is continued till the concrete is thoroughly consolidated. Each section of concreting should be as far as possible completed in one operation, but when this is impracticable, and work has to be recommenced on a recently laid surface, it is necessary to wet the surface, and where it has hardened it must be hacked off, made clean, and covered with cement grout. The concrete, when laid, should be protected from the action of frost, and shielded against too rapid drying from exposure to the sun's rays or winds, and it should be kept well wetted.

STRIKING CENTERING.

The time during which the centres should remain up depends on various circumstances, such as the dimensions or thickness of the parts of the work, the amount of water used in mixing, the state of the weather during laying, and the setting time of the cement, etc., and this must be left to the judgment of the person responsible for the work.

The striking of centering is a most important duty, and unless very carefully carried out may involve terrible consequences in the collapse of the whole work and loss of life.

Nearly all failures in reinforced concrete work—failures which, though happily absent in English experience, are not unknown in America and other countries—have been caused by a too early removal of the centering and struts from beneath newly made concrete and the premature loading of the structure.

It should be remembered that the dead load or weight of the structure, without reckoning the load for which it was designed, is considerable. In a floor slab having a 16-ft. span, the weight of the floor itself may be quite half as much as the live load which it is designed to sustain when the concrete is thoroughly matured.

Too great care and judgment cannot therefore be exercised in arriving at a decision as to when struts may safely be removed.

It is advisable to remove the side casing of beams at an early date to hasten the drying and hardening of the concrete ; but at the same time the soffit boards and struts should be left in position to hold up the floor until the concrete is set. The casing for columns, for the sides of beams, and for the soffits of floor slabs not more than 4-ft. span, may be removed after eight days ; soffits of beams and of floors of greater span should remain up for at least 14 days, and for large span arches for at least 28 days.

REINFORCED CONCRETE.

Now, to deal especially with reinforced concrete, the use of concrete reinforced with metal has made great strides throughout the world of recent years. It has been adopted abroad far more extensively than in this country, particularly in France, Germany, Austria, and the United States and Canada, and one has only to pay a flying visit to those countries to at once appreciate the application and utility of this practically modern system of construction.

Reinforced concrete, which is also termed ferro-concrete, armoured concrete, and concrete steel, may be described as a mode of construction where concrete and steel are applied in such a manner that the mechanical and physical properties of the two materials are utilised to the greatest possible advantage.

The concrete is invariably made with the materials and by the methods I have previously described, and the steel employed is of the type generally known as mild steel, in contradistinction to qualities of metal which are designated high-carbon steel or hard steel.

Reinforced concrete, however, can be made with any quality of iron or steel, the only reason for the adoption of mild steel being that the variety thus denoted is more reliable and more economical than any other.

Principles of Reinforced Concrete.—The primary principles of reinforced concrete are, that concrete is extremely strong in compression, but comparatively weak in tension, and consequently reinforced concrete is arranged to employ concrete to withstand compression stresses, and steel to resist tensile stresses. Steel is a strong ductile material which under modern conditions of manufacture is of great reliability. When embodied in concrete it imparts thereto the properties of ductility and uniformity that are possessed by itself.

Moreover, steel and concrete have practically the same coefficient of expansion and contraction under temperature changes. This property means that the two materials contract and expand together just the same, otherwise internal stresses would be set up and destroy their union. Concrete has a great adhesion for steel, and the two become so intimately united when the embedded steel is in small sections that they form in combination a new homogeneous constructional material.

Portland cement concrete has been used for so many years that its valuable properties and its limitations are thoroughly known. Capable of withstanding without injury the destructive influences of fire, air, and water, and possessing great compressive strength, it has relatively little tensile strength, although vastly superior in this respect to brick and various kinds of natural stone.

Steel, on the other hand, is remarkable for tenacity, but suffers from rapid deterioration when exposed to the air even when coated with the most efficient paint as a protective covering. It is, moreover, very susceptible to heat, and in case of fire, steelwork constitutes a serious danger to any building where it is employed in accordance with ordinary methods of construction. Here the concrete acts as an infallible protection to the embedded steel, preserving that steel not only from injury by heat in case of fire, but, for all time, from corrosion.

EFFECT OF COMBINATION OF MATERIALS.

In reinforced concrete, then, we have qualities of great resistance, continuity, elasticity, and incombustibility. It has in the highest degree the indispensable quality of homogeneity, and consequently within the last few years this system of construction has become recognised by the architectural and engineering professions to such an extent that we are now in a veritable " concrete age," this being the most up-to-date system of building, and the constructive method of the present and the near future.

PERMANENCE OF CONCRETE.

With regard to the permanence of this form of construction, every engineer knows that lime concrete employed by the ancient Romans has endured to our own times, and that iron embedded in the same variety of concrete has been preserved for thousands of years without a trace of corrosion. It is equally well known that Portland cement concrete is a far more durable material than the lime concrete formerly used, and therefore there can be no doubt whatever as to the permanence of works executed in reinforced concrete, wherein the steel reinforcement is embedded at such depths as to preclude the possibility of injury from fire, air, and water.

In every part of the world evidence remains to show that the valuable properties of concrete have been fully recognised from ancient times.

Vitruvius Pollio, a celebrated architect, who lived in the time of Augustus, Emperor of Rome, describes concrete as one of the most valuable building materials, which for centuries before his time had been used for foundations, walls, and all structures where great strength was required.

The great dome of the Pantheon, in Rome, 142 ft. in diameter, was built entirely of concrete, and remains to this day an example of durability, having resisted the destructive influences of nature for well-nigh 2,000 years.

In the House of the Vestals, an upper floor, of 20-ft. span, consisted simply of a concrete slab 14 in. thick without any reinforcement. There are also in Rome, and throughout the countries once forming parts of the Roman Empire, numberless examples of early concrete work, which have proved more durable than masonry construction.

All these, and other early works in concrete, contained lime as the cementitious material. As for the still greater capacity for endurance of Portland cement concrete little need be said. The absolute faith reposed in such concrete is abundantly evidenced in its universal employment by engineers and architects, and notably by its selection for such important works as the great National Harbour at Dover, the Keyham Docks Extension Works at Plymouth, and many other works equally well known, including various large reservoirs, breakwaters, and docks over the country, and other works which I will show on the screen later.

Probably the most remarkable characteristic of reinforced concrete is its ability to withstand excessive vibration and shocks without injury. A most convincing proof of this statement is the large number of reinforced concrete piles that have been successfully driven into ballast and other hard strata. In most cases the monkey weighs from two to three tons, and the blows come in sharp succession, so as to keep the pile always on the move.

Take the case of locomotives running over bridges and subjecting them to shock, small in quantity, but frequent in action, due to the engine travelling. In reinforced concrete it is observed that a bridge deflects under load, and springs back as soon as the load is released without developing any cracks.

The San Francisco and Messina earthquakes also gave striking examples of the resistance of reinforced concrete to shocks. Regarding settlement, it would be readily understood that reinforced concrete has a strong point here, as the whole structure is monolithic, and could take tension as well as compression. Any tendency to cant sets up tension in some member, which in ordinary construction makes itself evident by cracks and fissures.

Unlike timber, iron, and steel, which rapidly perish by natural decay or corrosion, and unlike stone or brick, which, more slowly but none the less surely, disintegrate and crumble away as the result of atmospheric influences, good concrete increases in durability and strength by continued exposure.

The striking instances already given are sufficient to establish this unique and invaluable property of concrete. The same property is still more highly developed in reinforced concrete, owing to the superior quality and the scientific proportions of the constituent materials, and in consequence of the close attention devoted to the thorough mixing of the ingredients, and the methods of depositing and tamping the resulting concrete, which are ensured by the practice of confining the execution of works to authorised contractors whose experience and standing give assurance of their perfect reliability.

ABSENCE OF METAL CORROSION.

In view of the doubts sometimes entertained as to the efficacy of concrete for the preservation of embedded metal, it is possible to obtain many well-established facts to show that the reinforcement in ferro-concrete is perfectly safeguarded from all risks of corrosion ; but perhaps it is hardly necessary for me to detail them here. At any rate, evidences of the indestructibility of reinforced concrete through the lapse of time are not wanting, and very many instances in support of this contention can readily be cited.

The late surveyor to St. Paul's Cathedral recently caused an opening to be made in the concrete of the dome in order that the condition of the great chain which binds it at its base might be disclosed. This chain has been embedded in lime concrete for more than 200 years, and it was found to be as bright and perfect as when new.

The reason why steel encased in concrete is prevented from rusting is that the oxide of iron chemically combines with the cement, forming a covering of ferrite of calcium, which is a good protective agent, and numerous experiments have shown that steel embedded in concrete for any number of years is found in the same condition as the day it was put in, and even where rusty steel has been used, it is seen that ultimately the rust has disappeared.

First Use of Reinforced Concrete in England.—Precisely when *reinforced* concrete was first used would be difficult to determine. The first patent taken out in this country was about the year 1850, by one named Wilkinson, but apparently the idea was not received with favour. In 1861 M. Coignet published in France a book in which he recommended the introduction of a metallic framework to strengthen concrete structures. In 1880 the system had received practical attention in France and Germany, while a bridge was built of the material in Denmark in 1872.

It was not until 1898 that reinforced concrete construction in the form of beams and piles was practically applied at Southampton by M. Hennebique, who was the pioneer of this form of construction in England. To-day, reinforced concrete has attained an important position among systems of engineering practice, and in the very near future few engineering works will be carried out without making use to some extent of a combination of steel and concrete.

DESIGN OF BEAMS.

It will now be convenient to examine the principles involved in the design of a simple beam freely supported at each end, and I would now direct your attention to the sketch shown in *Fig.* 1. Under the strain of an evenly distributed load, the bottom fibres of the beam are subjected to a tensional stress which tends to tear them apart, and which, by causing them to stretch and increase their length, enables the beam to bend under the applied load. It has been previously pointed out that concrete is not able to withstand this tensional stress, and that steel is well able to do so. It is therefore at the bottom of the beam that the steel must be applied.

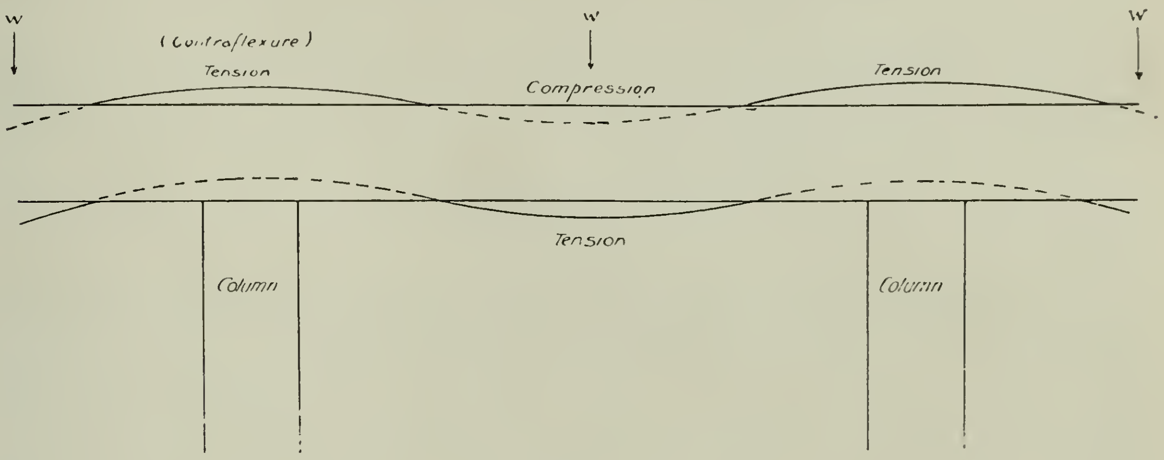


FIG. 1.

The top, as we know, is subject to compression, and it is in this portion of the beam that concrete is relied upon to take its share of the forces to which the beam will be subjected.

Few beams in engineering construction are, however, so simply designed as the one just cited. Beams are generally designed in the form of continuous beams being supported upon columns at three or more points.

The parts of such a beam which lie in the centre of the span between the columns have the lower part in tension and the upper part in compression. For a short distance over each column, however, the nature of the stresses is reversed, and the upper part of the beam is in tension and the lower part in compression.

This action will be readily understood from the diagram shown in *Fig.* 1, and in which it will be seen that the concave portions of the beam are in compression, and are denoted by dotted lines, while the convex sides are in tension.

At the point of contraflexure, as it is called, the steel bars, or a proportion of them, are bent in such a manner that they no longer run near the lower face of the beam, but come up to the top as they pass over the columns.

A further provision of steel is necessary by way of web reinforcement to resist shear. The function of web reinforcement is to connect together the compression and tension areas in a rigid manner in precisely the same way as the bars of a lattice girder or the members of a truss girder.

The shear which these members resist is greatest at the ends of a uniformly loaded beam and diminishes towards the centre. It is therefore necessary that shear reinforcement should be heavier at the ends than at the centre, or if the shear bars are of the same section throughout, they should be placed at gradually decreasing distances from the centre to the ends of the beam. The three principal points of reinforcement in beams are therefore :

The main tension bars at the bottom of the beam.

The tension bars at the top of the beam at points of contraflexure over columns.

The web or shear reinforcement connecting the tension and compression areas together.

REINFORCEMENT.

As to the method of the reinforcement of concrete, there are a number of systems—some of which are patented and others not—to choose from, but no particular system perhaps comprises all the essentials of an ideal reinforcement. Generally speaking, each system has features in which one or two details are superior to those of other systems, and perhaps this is a good reason why engineers should study the matter out for themselves.

The generally accepted method of reinforcement, however, is in the insertion of thin horizontal bars or rods and strips of steel in just those places, and in those places alone, where the stress diagram of any given structure shows that the resistance of the concrete requires to be supplemented.

The steel used is usually in the form of round bars and strip, obtained from makers of good repute, and should be produced by the open-hearth basic or acid process.

As regards the various sections of reinforcements used with concrete, firstly, we have to consider the ordinary commercial round or square bars. Small sections are generally favoured, as they give a larger proportionate surface for adhesion, and are more easily manipulated. Hoops, bands, and flats of small section are used, but rounds and squares are the sections usually used in reinforced concrete work. Other sections are, however, used, more particularly T-bars, which are specially fitted for reinforcing arches and tall chimneys, while the old type of steel and concrete floor, of which there is a considerable amount still constructed, has small I joists.

Some patent bars for reinforcement are moulded in various shapes and sizes with the idea of providing the mechanical bond which numerous authoritative investigations have shown to be quite unnecessary, owing to the natural bond created between the concrete and the steel by physical and chemical agencies.

Regarding the cost, speaking generally, reinforced concrete is from 10 per cent to 40 per cent. cheaper than ordinary construction, and this without taking into account the advantages already investigated. The first cost is the only cost, and maintenance charges, that are a constant worry and expense to engineers in charge of railways, bridges, docks, gasworks, etc., are entirely obviated.

WORK OF ERECTION.

Now, in making preparation for reinforced concrete work, I have already dealt with the method of concrete making. The steel reinforcement I have described, and the theory of design of such reinforcement I am dealing with later, so we will now confine ourselves to the practical methods of construction.

It will save considerable time if the steel is delivered cut to the required length, as by this means a good deal of smith's work on the job will be avoided. A convenient way of bending the smaller bars is to use a long temporary bench, constructed of thick timber with strong pins or plugs in the same to bend the bars upon. These pins should be arranged to form a template, and thus the work will be accurate and expeditious. Generally speaking, bars up to ⅝ in. diameter can be bent cold, but larger ones should be bent hot, and it is desirable that the heat at which they are bent should not exceed that of a cherry red ; a white heat is not desirable. Smooth bars, whether round, square, or hexagonal, must be anchored at the ends, either by bending at right angles, or by splitting open like a fish-tail, or by means of a washer and nut, the latter being probably the most effective method. Steel bars in floors and walls must be crossed to distribute the stresses, and bars in the beams must be cranked over the supports, irrespective of the system used. Where openings occur, either in floors or in walls, it is always advisable to put additional steel round the openings. The steel bars in the beams can either be suspended from above, or by the stirrups or shear hangers, or they can be carried on temporary wooden slips, or by concrete bolsters, in the bottom of the troughing. Generally speaking, it is not desirable to use wood slips, as workmen are frequently careless and forget to remove them ; concrete bolsters, on the contrary, are left in permanently, and become part of the beam. The bars in floor slabs can be kept the required distance above the centering by means of notched wooden templates, or by a round iron rod ; these are pulled along the floor just in front of the concrete as it is being deposited. Another method is by means of small concrete blocks which are embedded in the concrete, and become part of the structure. It is in every way desirable that all, or nearly all, bars where they cross each other should be wired together with soft iron wire, thus guarding against displacement when the concrete is being rammed around them. This takes a little while, but it is time well spent, and results in good homogeneous work.

LOADING TESTS.

The durability of reinforced concrete should not be difficult to prove, as it has already been shown that as long as the concrete covered the steel there was no need to have any fear. It is a well-known fact that concrete improves by age, and it is also known that the tensile strength and compressive strength of the cement also increases year by year.

Loading tests on the structure itself should not be made until at least two months have elapsed since the laying of the concrete. The test load should not exceed one and a half times the accidental load. Consideration must also be given to the action of the adjoining parts of the structure in cases of partial loading. In no case should any test load be allowed which would cause the stress in any part of the reinforcement to exceed two-thirds of that at which the steel reaches its elastic limit.

FOUNDATIONS.

With all buildings, constructed on no matter what principle, the foundations must conform to the ordinary types ; for instance, spread or raft foundations may be adopted, or piles and caissons used to sustain the loads. The latter—namely, piles and caissons—are used where heavy loads are to be sustained by a weak subsoil. Indeed, they are often used in water. For such a purpose reinforced concrete is distinctly suitable, as the steel is prevented from corrosion ; and apart from the question of cost, reinforced concrete piles are very superior, as regards life, to timber or steel piles.

It is essential in driving concrete piles that the blows be of a steady and uniform nature, and that a heavy hammer with a fairly short drop be used, otherwise there is a danger of damaging the pile and causing it to crack or " shatter." Again, the great weight that is represented by a long concrete pile necessitates special arrangements for the handling and hauling into position ready for driving.

As regards spread or raft foundations, reinforced concrete is particularly serviceable, because it produces the thickness of concrete that is ordinarily necessary. A very thin slab can be used, as the concrete is not called upon to sustain any tension, steel being used for this purpose at the lower side of the slab. Independent spread foundations are now reinforced with bars, although the older form of steel joists, crossing each other, is a form which is still much used. Where raft foundations are used, constructed without reinforcement, a great thickness of concrete has to be adopted, while even then they are deficient because the difference between heavy loads on various portions of the site, or a difference in the bearing power of the subsoil, puts a great strain upon the raft, and it is almost certain to result in cracking and unequal settlement. A reinforced concrete raft, however, can be constructed very much thinner, and thoroughly framed together with beams forming ribs. Such foundations give security against unequal loading and unequal support from the subsoil, and against shocks and vibrations of great magnitude, thus being particularly applicable in districts where liability of serious earthquake shock has to be feared.

GENERAL DESIGN.

A great many retaining walls have been built in reinforced concrete. Steel reduces the thickness, because buttresses, with thin intermediate slabs and a projecting foot, can be designed to be thoroughly stable against overturning and shear. There are no special systems with regard to reinforcing retaining walls that call for notice.

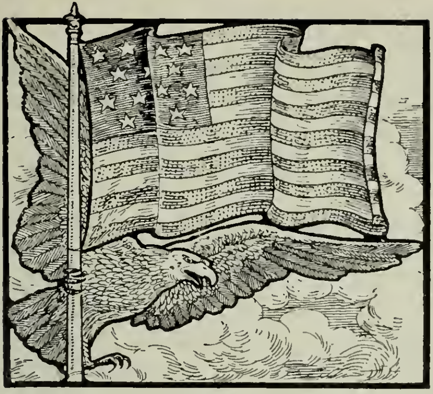
Columns, piers, posts, or stanchions are constructed of reinforced concrete, the reinforcement being used to reduce the section of the concrete, to bind it together, and to prevent bulging. The reinforcements consist, therefore, of longitudinal bars and horizontal ligatures, formed either of links or spirally-wound rods, generally of smaller section than the longitudinal bars.

In ordinary cases, there is very little lateral pressure on walls, and an ordinary square mesh-work embedded is sufficient. In reinforced concrete work, most buildings are carried out on the frame principle, the loads being carried from the beams on to columns, and the walls are mere partitions between them.

The reinforcement in arches and arched bridges constructed of reinforced concrete serves three purposes—namely, to take compression, to resist tension, and prevent shearing and temperature cracks. The reinforcement is designed in conformity with the modern theory of the elastic arch, and often hinges are introduced so as to ensure the line of stress passing through given points. Every endeavour, of course, is made to prevent tension in the arch ring, and the reinforcement chiefly serves to assist in the resistance of the compressive stresses. Consequently, large steel members such as tees are frequently adopted.

Trussed bridges of various forms are constructed in reinforced concrete, but no special principles are introduced in their design, the members consisting of posts, perpendicular or inclined, and beams of cantilevers.

Reinforced concrete is now extensively used in the construction of conduits, water mains, and sewers. The latter are usually constructed *in situ*—that is, the concrete is mixed and placed to set in the position it will finally occupy, although a great number of sewer pipes of large diameter are manufactured and sold as an ordinary market commodity. Water pipes are occasionally constructed *in situ* ; but, as a general rule, are made in moulds. The reinforcement is generally of spiral form, consisting of meshwork, the strands preferably crossing the pipe at an angle, and not running longitudinally and at right angles to the length. The spiral reinforcement serves to resist the bursting pressure. Expanded metal has been largely used for this purpose ; while wire meshwork has also been used. In one system called the Bonna system, special cruciform bars are wound spirally inside and out of a thin sheet of steel, the steel serving to prevent percolation under great pressure or contamination by penetration of external moisture in the soil.



CONCRETE CONSTRUCTION IN THE PANAMA CANAL.

(Conclusion.)

By JOHN GEO. LEIGH.

The construction of the Panama Canal is certainly one of the greatest engineering feats ever accomplished, and we feel sure that an account of the concrete work in this great undertaking will interest our readers. The first and second articles on this subject appeared in our May and June, 1911, numbers.—ED.

Government* v. *Contract Work.—Consideration of the vast quantity of cement required and of the dependence upon the quality of this material for the success of lock construction had much to do with the—in the writer's opinion—very wise decision that the Canal should be built under the direct control of the United States authorities, and without recourse, on any large scale, to contract work. The last hybrid Commission of civilians and military men favoured a contrary policy, but with its fall in March, 1907, and immediate supercession by a Canal administration composed almost exclusively of officers of the Corps of Engineers, U.S.A., its schemes in this and other directions suffered sudden eclipse.

In the first annual report published under his auspices, Lieut.-Colonel G. W. Goethals, the new and present chairman and chief engineer, argued very temperately, but with irresistible cogency, against the intervention of contractors. Dealing specifically with the concrete work, he pointed out that, owing to the considerable distance between the isthmus and commercial centres, the Government would be able to construct the locks and dams more cheaply than could a contractor ; that the latter would probably find, after the completion of the work, no further use for the special machinery installed, even if the payment of freight for its return to the States were warranted ; that the plant could be procured more cheaply by the Government ; and that if it were furnished by the contractor, the Administration would have to pay for it in its entirety, together with interest on the amount expended on its purchase. Owing, moreover, to the close and peculiar association of the United States military engineers with constructions of like character, cheaper and incidentally better concrete work might be expected from them than from less specialised supervisors.

Cost of Canal Completion.—According to a revised and detailed estimate prepared by the Isthmian Canal Commission in December, 1908, the expenditure by the United States in connection with the completion of the enterprise will be £77,362,000. This amount, it should be noted, includes the £8,427,000 paid to the second French Canal Company for all its rights and properties ; £2,107,000 paid to the Republic of Panama for sovereign powers in the Canal Zone ; loans to the Panama Railroad, and expenditure on waterworks and other improvements in the cities of Panama and Colon—items under the last two heads being, of course, repayable to the United States Treasury ; but excludes reference to the expenditure of £2,573,000 now proposed for fortifications. Among the classified estimates making up the grand total are :

Excavation, dredging, etc., Central division	£18,239,000
Limon Bay breakwaters	2,357,000
Gatun locks	5,325,000
Gatun dam	2,800,000
Excavation, dredging, etc., Atlantic division	3,656,000
Excavation, dredging, etc., Pacific division	2,715,000
Pedro Miguel locks and dams ...	£2,670,000
Miraflores locks and dams	4,509,000
General expenses	4,895,000
Sanitation	4,134,000
Civil administration	1,522,000
Construction and repair of buildings	3,000,000
New Panama Railroad	1,700,000

Concrete Revetment in Culebra Cut.—It is yet uncertain to what extent it may be found necessary or desirable to protect the faces of Culebra Cut. Owing to the large expense to which they would be committed by the adoption of any ambitious scheme of revetment, the Commission have wisely determined, pending the complete excavation of the Cut or the occurrence of the unforeseen, to limit immediate attention to a single point. This is at Paraiso, on the east side of the Canal, where frequent slides have demonstrated the necessity of revetment in order to preserve for construction purposes the berm, or ledge, 95 ft. above sea-level, proposed originally to accommodate the Culebra section of the relocated Panama Railroad. The length of wall to be retained is about 900 ft., and for this work and other of similar character which may hereafter be deemed necessary, special equipment has been requisitioned.

Cost and Progress of Lock Building.—In the appended table, dealing specifically with the more important concrete constructions, are shown : (1) The Canal Commission's estimate of work required for Canal completion and its probable cost ; (2) dates when work commenced at the various points ; (3) totals up to March 31st, 1911 ; and (4) concrete placed between that date and May 21st.

——	Estimated concrete masonry required and unit cost.		First concrete placed.	Quantity and cost to March 31, 1911.			Concrete placed April 1 to May 20, 1911.
				Concrete placed.	Total cost.	Unit cost.	
	cu. yd.	$		cu. yd.	$	$	cu. yd.
Culebra Cut revetment	400,000	1.000	—	—	—	—	—
Gatun Dam Spillway	250,000	8.25	Mar. 17, 1909	131,092	1,063,499	8·1126	4,895
Gatun Locks, including approach walls	2,086,000	7.75	Aug. 24, 1909	1,234,430	8,973,744	7·2695	118,499
Ironwork ...	—	—	—	—	775,216	—	—
Pedro Miguel Locks, including approach walls and core connection with dams ...	916,166	8.25	Sept. 1, 1909	599,043	3,212,692	5·3630	52,037
Miraflores Locks ...	1,430,199	8.25	May 30, 1910	173,115	894,236	5·1656	71,821
Ironwork ...	—	—	—	—	446,698	—	—
Miraflores Dams ...	75,100	11.00	—	—	430	—	—

Unit Costs.—The following table, showing the detailed cost per cu. yd. of concrete masonry in Gatun spillway and the several locks for the quarter ended December 31st last, will, it is hoped, prove interesting to a very considerable proportion of readers :

——	Gatun Spillway.	Gatun Locks.	Pedro Miguel Locks.	Miraflores Locks.
Concrete :				
Quantities (cu. yd.)...	18,353	220,169	167,758	65,805
Cement	$1.8012	$1.8433	$1.4124	$1.3930
Stone	2.2934	2.1359	0.7450	0.7540
Sand ...	0.4594	0.8693	0.3797	0.3828
Mixing	0.1779	0.1873	0.1661	0.6440
Total cost	$4.7319	$5.0358	$2.7033	$3.1738
Large Rock :				
Quantities (cu. yd.)...	310	21,872	746	1.758
Cost	$2.7998	$1.1909	$0.8231	$1.1993
Masonry :				
Quantities (cu. yd.)...	18,633	242,041	168,504	67,563
Concrete	$4.6534	$4.5808	$2.6913	$3.0911
Large rock ...	0.0465	0.1076	0.0036	0.0312
Wood forms	0.4555	0.3574	0.3243	0.3754
Steel forms ...	—	0.0938	0.0495	0.1245
Placing	0.6817	0.3896	0.2910	0.2762
Coffer dams ...	0.0719	—	—	—
Reinforcements	—	0.0307	0.0114	0.0106
Pumps	—	0.0293	0.0356	0.0488
Power	—	0.0745	0.0418	0.0160
Maintenance of equipment	0.2141	0.2616	0.1840	0.1750
Plant arbitrary	0.6160	0.6850	0.6649	0.4500
Division expense	0.1165	0.1050	0.0752	0.1205
Administration and general expense	0.2627	0.2386	0.2721	0.3511
Total cost	$7.1183	$6.9539	$4.6447	$5.0704
Masonry, Reinforced :				
Quantities (cu. yd.)...	—	272	—	—
Cement	—	$3.1200	—	—
Stone	—	2.3193	—	—
Sand ...	—	0.8800	—	—
Forms	—	2.4209	—	—
Mixing	—	5.1736	—	—
Placing	—	1.8031	—	—
Reinforcements	—	2.1729	—	—
Plant arbitrary	—	0.6850	—	—
Division expense	—	0.7792	—	—
Administration and general expense	—	1.7682	—	—
Total cost	—	$21.1222	—	—
Total Masonry :				
Quantities (cu. yd.)...	—	242,313	—	—
Total cost	—	$6.9698	—	—

Since this table was compiled the writer has been placed in possession of corresponding figures for the quarter ended March 31st. Taken generally, these show a considerable reduction, as compared with the foregoing figures, in the cost of concrete laying in both the Atlantic and Pacific divisions. The cost of the concrete placed in Gatun Locks during the quarter—231,907 cu. yd.—was $6.6972 per cu. yd., this price including 3,314 cu. yd. of reinforced concrete, used in the construction of the operating tunnels, at $14.276 per cu. yd. In March, 86,884 cu. yds. of concrete were placed in the locks, and of this amount 1,585 cu. yd. were reinforced, the cost of the latter being $13.9034, and of the mass concrete $6.315 per cu. yd. The cost of the crushed stone brought from Porto Bello shows, as compared with the figures of the preceding quarter, a reduction of 21.11 cents per cu. yd., but that of the sand dredged at Nombre de Dios was slightly in excess.

There was a small increase in the cost of concrete at the Pedro Miguel Locks, due to the lesser amount placed consequent upon the removal to Miraflores of part of the construction plant. The unit price of $5.2131, however, compares very favourably with the estimate of 1908. At Miraflores, in spite of the fact that only a portion of the plant was in operation, the quarter's production of concrete was 76,087 cu. yd., and the cost thereof but $4.8434 per cu. yd.

It will be noted that, in the endeavour to arrive at a just estimate of unit cost, consideration has been paid to all establishment and other charges, excepting only items of expenditure for sanitation, hospitals, and civil government. The comparatively small cost of ironwork for reinforcement is explained by the fact that extensive use has been made of the vast store of 60 lb. and other light rails—of an aggregate length of nearly 250 miles—inherited from the French companies, of little or no worth for other purposes and consequently valued as " scrap."

Other Uses of Concrete.—Apart from the great constructional works to which particular reference has been made, concrete has been, and will continue to be, used on the isthmus for a significant diversity of purposes. For instance, it is interesting to note that during the first four and a half years of the American occupation, orders were placed by the Canal Commission for 203,730 barrels of Portland cement. Delivery was made in small quantities, the loss by broken packages and deterioration during transit being about 3 per cent. for cement shipped in bags, and about 10 per cent. in the case of shipments in barrels. Owing to the urgent demand for it, the material seldom remained long in storage, and consequently little was known as to the effect of the moist atmosphere, though tests showed that the sea voyage exercised but slight or no deteriorating influence.

Of the imports referred to, about 75 per cent. was used by the Department of Municipal Engineering in laying pavements, drains, sewers, etc., the remainder being employed by the Division of Building Construction. A considerable amount was utilised in the new Administration building at Ancon, a three-storey structure of concrete blocks, which would have cost double the amount spent upon it had it been built of bricks or stone. For reservoirs, water tanks, and storage houses for dynamite, powder, and detonators, concrete proved especially valuable. A plant for making the blocks was installed at Ancon as early as 1905, and was maintained for several years with ever-increasing effectiveness, the final cost of the manufactured product being 12½ cents per cu. ft. The mixture used was 1 part cement, 3 parts sand, and 3 parts stone chips, and when about three months old, blocks thus made showed a tensile strength of 342 lb.

More recently, extensive use has been made of concrete for bridges and culverts required in connection with the relocation and rebuilding of the Panama Railroad, rendered necessary by the creation of Gatun Lake. All future buildings of the railway will, so far as practicable, be of concrete construction ; and an important movement has been inaugurated at Colon, as a result of the recent disastrous fire, which will lead, it is believed, to a municipal regulation forbidding any but fireproof construction in certain areas. In the meanwhile, in order to encourage such construction, the Canal Commission and railway authorities are proposing to make concrete blocks for sale at the lowest practicable price, and also to establish a gravel storage in or near the city from which concrete builders may draw supplies.

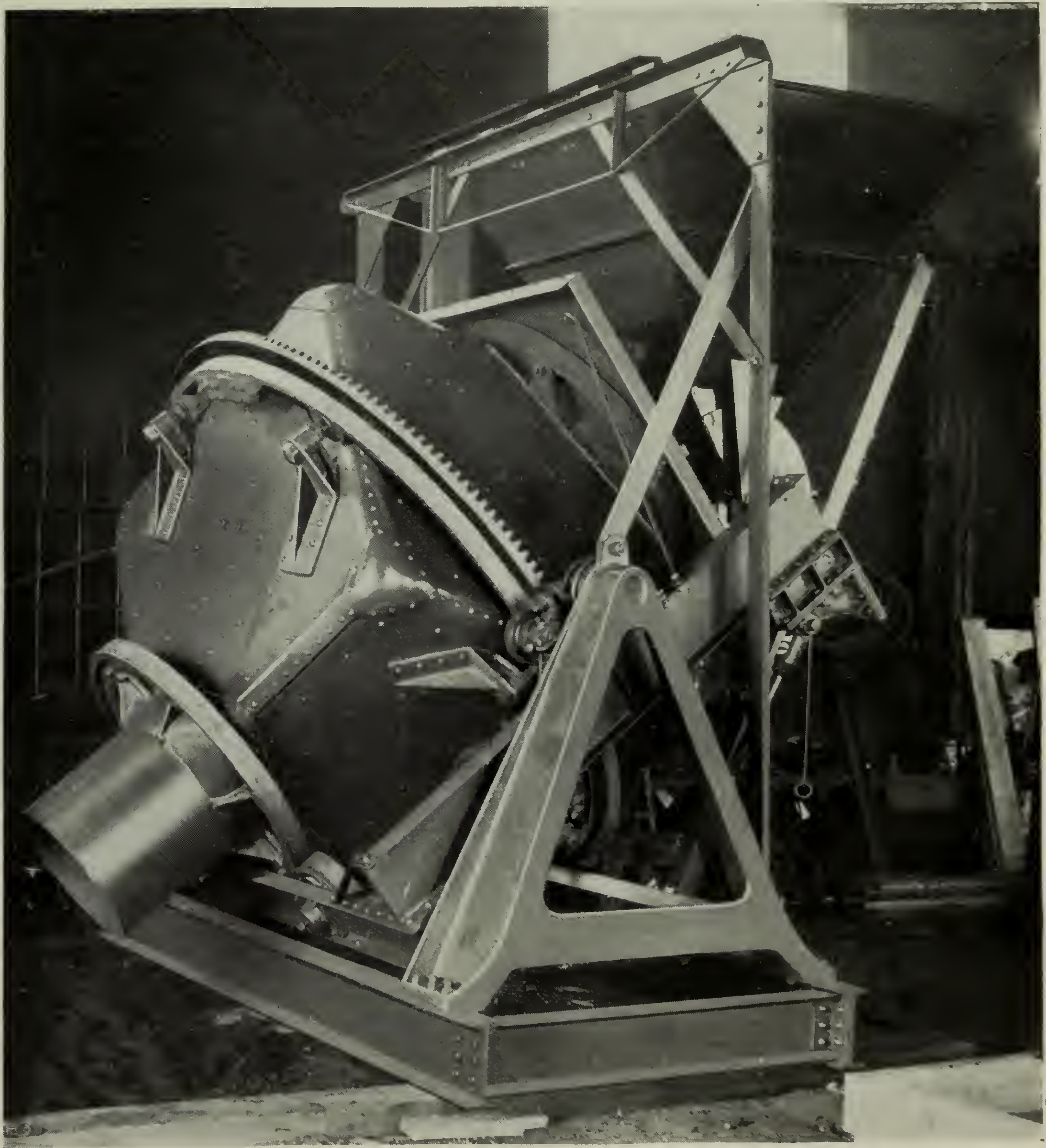


FIG. 22. 75 cu. ft. "Chicago" Mixer.
THE CONSTRUCTION OF THE PANAMA CANAL.

Plans are now being prepared for extensive harbours at each terminal of the Canal—at the Atlantic end, on each side of the channel at the north end of Limon Bay, and on the Pacific side at Balboa ; and in both cases the masonry will be of concrete. For immediate purposes, dock facilities at Balboa are to be increased (1) by remodelling the steel pier now in use, and (2) by constructing a

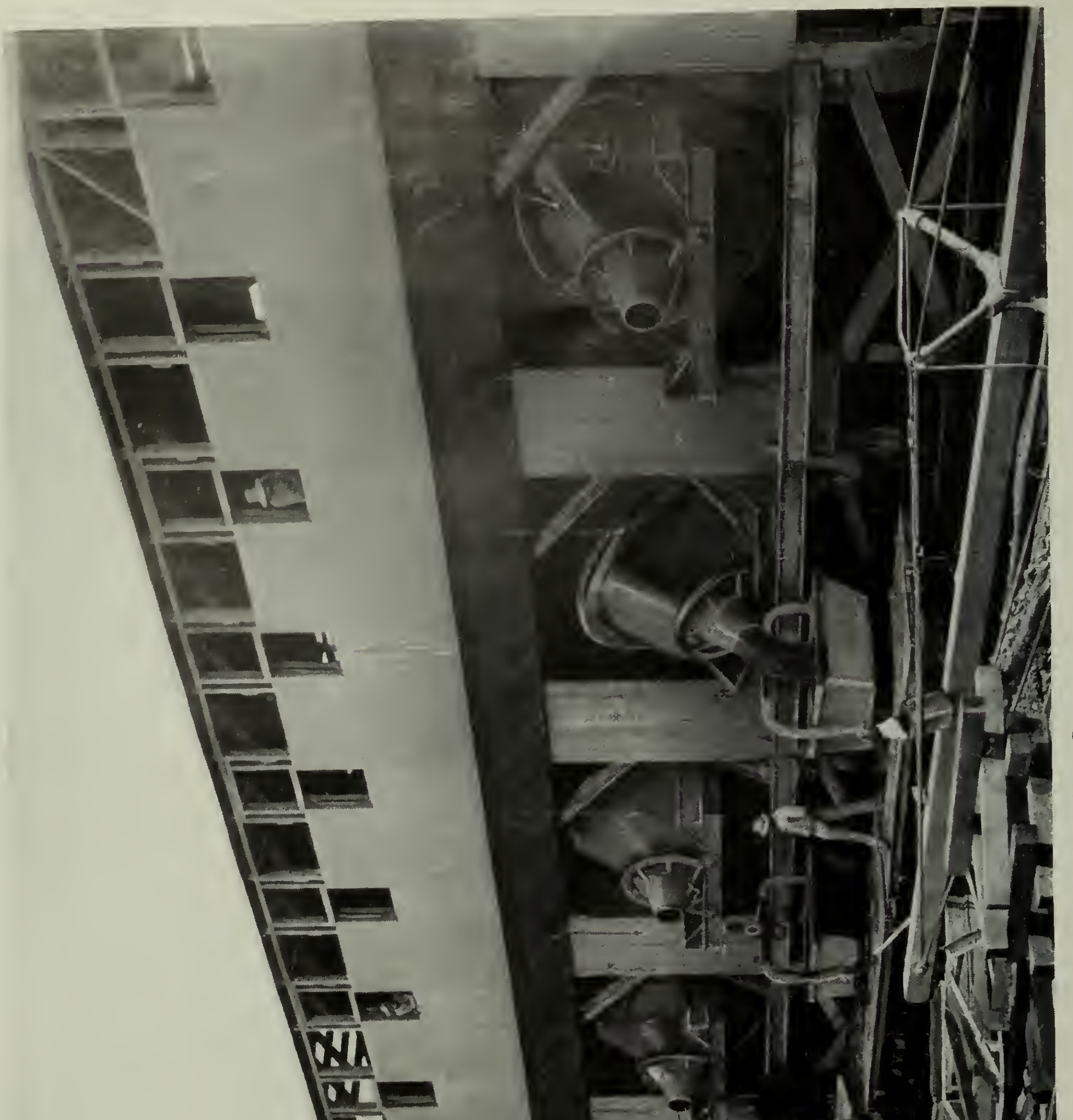


Fig. 23. Concrete Mixing Plant, Gatun.

The Construction of the Panama Canal.

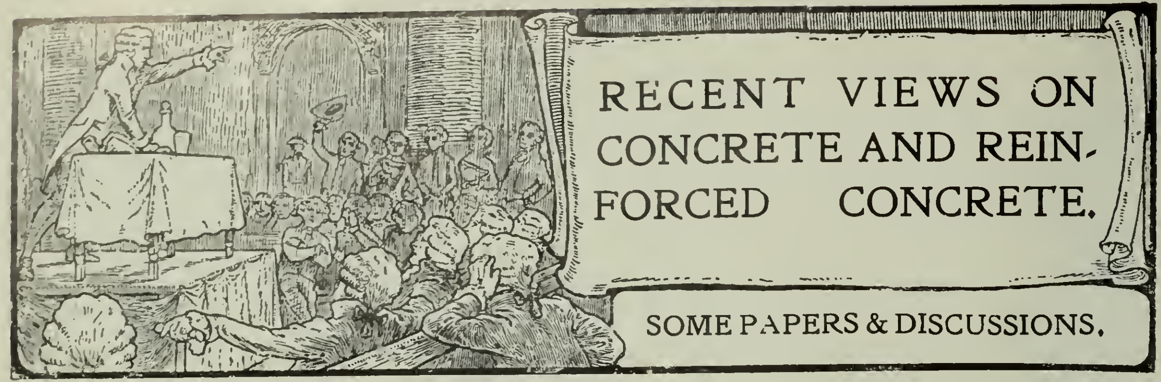
concrete dock along the proposed anchorage basin north of the dock at present used for sand unloading. The reinforced concrete dock will be 700 ft. long and 57½ ft. wide, and is estimated to cost about £29,000, in addition to the £45,000 required to defray the expense of dredging a 300-ft. channel leading to it. The preliminary plans provide for 8,200 cu. yd. of excavation for the piers for the dock, 7,000 yd. of concrete in the piers, 2,100 cu. yd. of concrete in the floors, 624 lb. of steel reinforcement, and 25,000 cu. yd. of backfilling. This dock will form part of the " safe and commodious " harbours at the Atlantic and Pacific ends of the Canal, provided for in the Act of Congress of June 28th, 1902.

Concrete Mixing Plants.—Most of the concrete mixers installed at the various locks have capacities per batch of 75 cu. ft., ¾ cu. yd. or ½ cu. yd., and are of two types, manufactured respectively by the Municipal Engineering and Contracting Company and the T. L. Smith Company, both of Chicago. The largest machine, known in America as the " Chicago improved cube concrete mixer," is, to all intents and purposes, an adaptation of the first form of machine to be used extensively in the concrete industry—namely, the cubical box, journalled at diagonally opposite corners, and having a door on one side through which the charge of cement, sand, stone, and water was filled and the batch of mixed concrete was emptied. Though mechanically crude, these machines produced an excellent concrete, the main objections to them being that, to discharge, the cube had to be stopped with the door at the bottom, and, to be recharged, had to be turned until the side containing the door came to the top—further time, of course, being lost in unclamping and reclamping the door.

In the improved machine (see *Figs.* 22 and 23), which preserves the principle of treating the batch as a unit, includes both longitudinal and rotary movements, and mixes by kneading and not by stirring, many interesting modifications have been introduced. For example, the shaft of the older machines is replaced by hollow trunnions riding on rollers, and made sufficiently large to serve as openings for charging and discharging. To rotate the cube, a strong circumferential rack is fastened around it at right angles to and midway between the trunnions; and this rack, geared with a pinion shaft, is so operated by the engine shaft that all gearing is removed as far as possible from the material which flies about during the charging and discharging operations. An automatic dumping device has been provided, and, to ensure the construction of a larger cube in the same space and eliminate any opportunity for pocketing the fine mortar, the former sharp corners and edges are rounded

Each cube is provided with breaker rods, from ⅝ in. to 1 in. in diameter, so placed across each of the six central corners of the cube that as the machine revolves they slice through the mass of concrete, each following a different line, and effectually breaking any baked lumps or cakes found in the materials. Otherwise, the interior of the cube is free from paddles, deflectors, or other obstructions.

The Smith mixer is likewise charged and discharged without stopping. In this machine specially arranged blades combine, with the double conical shape of the drum, to produce an alternating sideways movement of the materials simultaneous with the " rolling over " movement of the batch, assuring a perfect mix practically as soon as the materials are put into the machine. The side-loading attachment tends to materially reduce labour costs, and at the same time increase the capacity of the mixer. A more detailed and fully-illustrated description of this machine was published in our June issue.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CANADIAN CEMENT AND CONCRETE ASSOCIATION.

CONCRETE SURFACE TREATMENT.

Paper by Mr. ROBERT CATHCART.

The Third Annual Convention of the Canadian Cement and Concrete Association was held in Toronto in March last. Many interesting and instructive papers were presented on that occasion, and in this issue we give a summary of that read by Mr. Robert Cathcart on "Concrete Surface Treatment." We shall deal with the others at a later date.

The plans and modes of surface exterior treatment to large, massive work, such as bridges, abutments, reservoirs, etc., sometimes to exterior factory construction, are operated by both the mechanical and chemical treatment.

Mechanical treatment is executed either by skilled or unskilled labour, or mechanical devices, in the following manner—picked, scraped, rubbed when green, bush hammered, tooled, sand blasted, etc. All of the treatments are more or less expensive; in many cases the workmen have stunned the corners, and the surface generally gathers dust and dirt from the atmospheric gases, which tend to destroy or disintegrate the surface in time. They generally are for effect only and give no great weather resistance to the surface. In fact, they are unfavourable to many conditions of construction, and in some cases only a makeshift to betterment.

Chemical Treatment.—Chemical treatment is also an unskilled or skilled labour treatment, with commercial muriatic acid, acetic acid, etc., diluted in water, consisting of cutting the scum surface to relieve the hidden aggregates. It is also a more or less expensive operation, and the non-uniformity of the surface, combined with its chemical action, does not put it into special favour, although such processes have been patented. The muriatic acid is liable to stain the surface, and leave salts that will form a soluble alkali in combination with the concrete and produce an efflorescence on the surface.

Veneer Treatment.—The veneer treatment to outside walls, with plaster, has proven quite unsatisfactory for many reasons. The bond to the concrete has generally been weakened by the percolation of water through the plaster to the concrete surface which has caused a loss of adhesion, strength and permeability.

The outward influences, such as the sun's rays, frost, rapid wetting and drying, cause shrinkage of the veneer surface, loosening all soundness of adhesion, resulting in cracking and scaling.

Thus it would look as if no plaster should be applied to exterior walls where dampness could possibly lodge itself

Coated Surfaces.—Coated surfaces are those, generally speaking, that have had cement grouts or washes applied to them. These are never stable, and are generally used to fill up the unevenness of the surface without regard to their lasting qualities. In fact, they are dangerous surfaces to apply any surfacing materials to because of the unstableness of the bond.

Floor surfaces are tricky, because no man finishes the entire area of surface, and they should be rigidly covered by inspection before operating any treatment.

The obstructions or obstacles to concrete surfaces that demand treatment for preservation and service are external influences on concrete surfaces, such as heat, cold, sunshine, water pressure, percolation, show their effects in two forms of disintegration—mechanical and chemical—defined as follows :

Mechanical.—A consequent washing away of the softer constituents from the surface by the softening action of water, due to frost, the alternating action of the sun's rays, resulting in a periodical expansion of the other surface.

Chemical.—The proportion of carbonic acid gas, oxygen, water, and gaseous products of combustion in the atmosphere, a separation of scales, sometimes thin and thick, which by accumulation and an infiltration of strange matter into the pores cause a peeling from the surface. In other words, you get a condition of disintegration or corrosion, from both within and without, which has been termed " wall rot proper."

The lodging of the soluble salts upon the surface is efflorescence, and mainly due to such conditions as above mentioned, although local conditions and materials govern its area of trouble.

The Need of Coatings and Kind of Materials.—To produce a material for surface coating on concrete has been widely discussed pro and con by all scientific bodies. Plaster has been found to be unreliable for exterior surface ; grouts are unstable.

To obtain an alkali and acid-proof vehicle with a pigment that will have sufficient wearing body has been the aim of the engineer, contractor, consumer, and manufacturer. Thus we will consider a few of the essential factors :

1. Materials should contain a vehicle and pigment working in harmony with the conditions upon the surface.
2. They should contain an acid and alkali sun-proof colour and pigment.
3. They should be sufficiently heavy to fill the surface voids and stop suction.
4. They should have a sufficiently hard-wearing surface to allow successive coats without further treatment of the surface.
5. They should produce a finish sufficiently close to the texture and originality of the surface.

Treatments.—Treatments of concrete surfaces are divided into two divisions, as follows :

1. The shallow or superficial method of treatment is a filling of the voids near the surface without discolouration. It is one that was much sought after in the early stages of concrete work, especially on concrete blocks, etc.

Although the monolithic type of construction has gained more favour in larger construction, the mechanical and chemical treatments of surfaces, as outlined, are the surfaces most in need of a shallow or superficial treatment.

Cement bricks, blocks, cast stone, are also surfaces that need a light treatment.

2. The physical or external method or treatment is a coating of natural materials as a preventive of contact between the elements and the construction. The treatment should be defined under two divisions :

(1) Damp-proofing and decorative, without complete obliteration of the texture of the surface.

(2) Water-proofing only, without the decorative feature, and complete obliteration of the texture of the surface.

Under the first division you have a combination of results against the mechanical and chemical disintegration of the surface as defined for exterior surfaces. The operation should be twofold in its purpose—damp-proofing and decorative in one operation, without destroying the texture of the surface.

Under the second division comes the subject of water-proofing (defined by Webster as proof against penetration), which may mean everything or anything, and we are sure the word has been handled improperly as to its meaning, because of our undying enthusiasm on the subject, although it may only mean damp-proofing, instead of water-proofing.

Water-proofing is an engineering problem of much discussion pro and con and does not enter into the subject of concrete surface treatment.

Specifications.—The following essentials should be strictly adhered to to ensure results for the surfacing of concrete :

All exterior or interior surfaces must be free from loose scales, sand, grit, oil or other foreign matter. Surfaces can be freed of such materials by either scraping, wire-brushing or scrubbing with carborundum brick.

No muriatic acid or other acid treatment should be used unless the surface is afterwards thoroughly neutralised by water or a light alkaline solution.

Green surfaces should be treated with a thin coat of surfacing materials to aid the neutralisation of the free lime, and to fill the voids upon the surface.

After the first coat is applied evaporated patches should be re-coated to ensure evenness on the future coats. All surfaces should be dry and free from moisture, to give perfect adhesion. Exterior surfaces of buildings should be protected from rain or heat while drying.

Costs.—Physical or external treatment : The figures, including the cleaning and preparing the surface under ordinary conditions on two-coat work, are generally estimated at 25 c. to 40 c. (1s. to 1s. 10d.) a square yard.

The covering of a concrete surface is about one-half that of lead and oil on wood, first coat ; and two-thirds of lead and oil on wood, second coat ; and equal to lead and oil on wood on the third coat for exterior surfaces. The labour for the physical coat treatment is about one-third greater than the application of lead and oil on wood for exterior surfaces.

On concrete floors the covering of a concrete coating or dressing runs from 200 sq. ft. per gallon, first coat, to 400 sq. ft., second coat, according to condition of surface.

The shallow or superficial method or treatment on coating two coats costs about one-third to one-half per sq. yd. less than the superficial or external treatments, depending upon conditions.

The operator must be careful of the first or priming coats, as they are the foundations for a perfect bond and neutralisation of the surface for successive coats. The operator should produce a surface texture without destroying the originality of the surface.

No surface is free from dirt and foreign matter, and it requires the removal of such substances, either by wire brushing or a light acid treatment, to remove stained portions, in order to secure a firm bond and penetrating quality to the surface.

NATIONAL ASSOCIATION OF CEMENT USERS.

WATERPROOFING WITH WATER.

Paper by CLOYD M. CHAPMAN.

Below will be found the text of a paper read by Mr. C. M. Chapman before the Seventh Annual Convention of the National Association of Cement Users of America.

It is of the first and greatest importance in the making of a waterproof concrete that the sizes of the particles shall be so proportioned that the mass shall be of maximum density, and therefore of minimum voids. Yet, after the utmost diligence has been employed in the selection of the mixture and in the proportioning of it, there are other factors still to be considered, one of which, very often not considered, is the amount of water to be used.

It has long been recognised that the quantity of water used in mixing concrete has a large influence upon the impermeability of the resulting mass. This fact has been well established, and most works on the subject of concrete, however brief, call attention to it. That impermeability may be regulated to some extent by the amount of water used is of great importance to the concrete trade. It is perhaps of as great importance to the block makers as to any other branch of the industry. We frequently read the claims of the block machine makers to the effect that this or that machine produces an impervious block, because it is made " wet," or " semi-wet," or " dry," but we doubt whether it is generally realised what a large difference in permeability a small difference in the percentage of water used will make.

The theory is generally held, we believe, that other conditions being the same, a wet mixture makes a more waterproof concrete, and that a dry mixture produces a more porous mass, unless very tightly compacted by much hard tamping or enormous pressure.

It was in an endeavour to make a very spongy porous concrete for a special purpose that Westinghouse, Church Kerr & Co. made up a series of blocks with varying percentages of water, and noted the great difference in porosity made by slight changes in the percentage of water used. The blocks used in this series of experiments were about 3½ in. by 3½ in. by 2 in. high, with a circular depression or cup in the top about 2½ in. in diameter, and 1 in. deep.

Some of these blocks were made of 1 : 2 and 1 : 3 mixtures of Portland cement and a good grade of building sand, while others were made of the same mixtures of cement and crushed granite screened through a five-mesh sieve.

The moulds were of wood, and the mixtures were tamped in by hand with a light tamper. A metal bell was used to form the depression or cup. In some cases the blocks were allowed to set in a damp closet for 24 hours before being exposed to the air; while in other cases the blocks were left in the air to set as soon as made. The day after being made the inside surface of the depression was brushed with a wire brush to remove any cement film or laitence from the surface, which might affect the results. When the blocks were one week old, 30 cubic centimetres of water was placed in the depression of each block, and the time noted which was required for the block to absorb all the water.

After the first test the blocks were allowed to dry out, and were again tested at two weeks old. After the second test they were exposed to the weather on the roof and tested again at the end of a month. Many blocks were made of each mixture of materials and of each percentage of water, and the average time taken in absorbing the water was used in comparing results. In all about 230 blocks were made and tested.

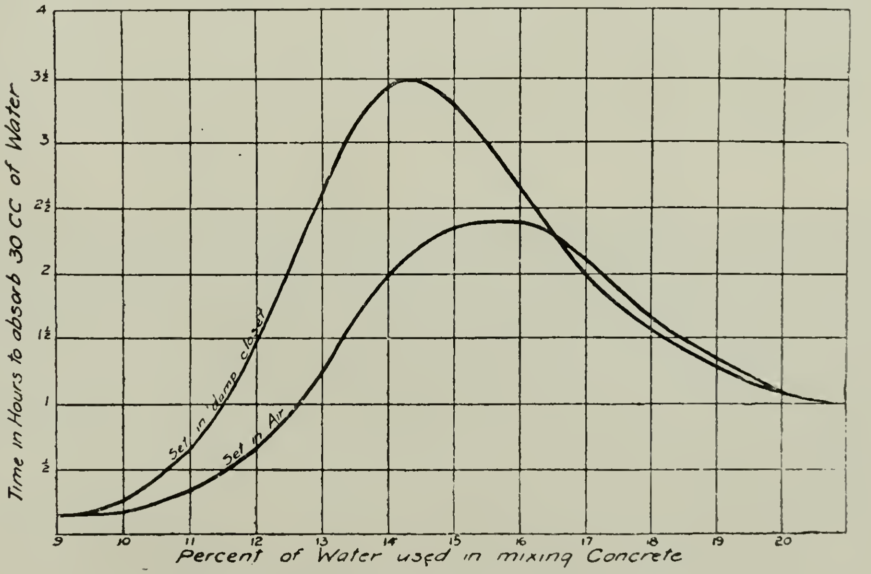


FIG. 1. DIAGRAM SHOWING RATE OF ABSORPTION.

The curves in *Fig.* 1 show graphically the results obtained at the first test when the blocks were one week old. The upper curve represents the results obtained on the blocks which were placed for 24 hours in a damp closet before being exposed to the air, and the lower curve shows results on blocks dried in air immediately after making, and not sprinkled. The ordinates represent the time in hours required for the block to absorb 30 cubic centimetres of water placed in the depression, while the abscissæ represent the amount of water used in percentage of the total weight of cement and aggregates. It will be noted that the results obtained with blocks which set in the damp closet were considerably better than those obtained with the blocks which set in dry air. There was so little difference between the results at the end of a week and those at the end of two weeks and one month that only results at the age of one week are shown. The other curves would practicaly coincide with these. While the best percentage of water probably varies with different cements and aggregates, and should be determined for any particular combination that is to be used, yet it is evident that for the cement and sand used in these experiments the amount of water should lie between 13 per cent. and 16 per cent. of the total mixture by weight, if the blocks are to be cured in a damp place. When exposed to the air immediately after making, somewhat more water should be used—say, between 14 per cent. and 17 per cent. The point we wish to emphasise is the importance of using the right amount of water. We cannot state that under other conditions the percentages given here will be correct. The above experiments indicate, not the amount of absorption of the blocks, but the rapidity or rate of absorption.

After the blocks had had their third test at the age of 30 days, they were dried out for a week in a warm room, carefully weighed, and then immersed for 24 hours in water. The surplus water was then wiped from their surface, and they were weighed again. *Fig.* 2 shows graphically the results of this series of absorption tests. In this curve the ordinates represent the percentage of water, by weight, absorbed by the dry blocks during 24 hours' immersion, while the abscissæ represent the percentage of water, by weight, used in mixing the concrete. The relation to the former curves is at once apparent. The least absorption occurs with about 14 per cent. of water, and it is fairly uniform between 13 per cent. and 15 per cent. By either method of determination—that is, by rate of absorption or by amount of absorption—we arrive at the same conclusion. A concrete may be too wet or too dry to produce the most impermeable product, and one extreme is as surely an evil as the other, if it is impermeability we seek.

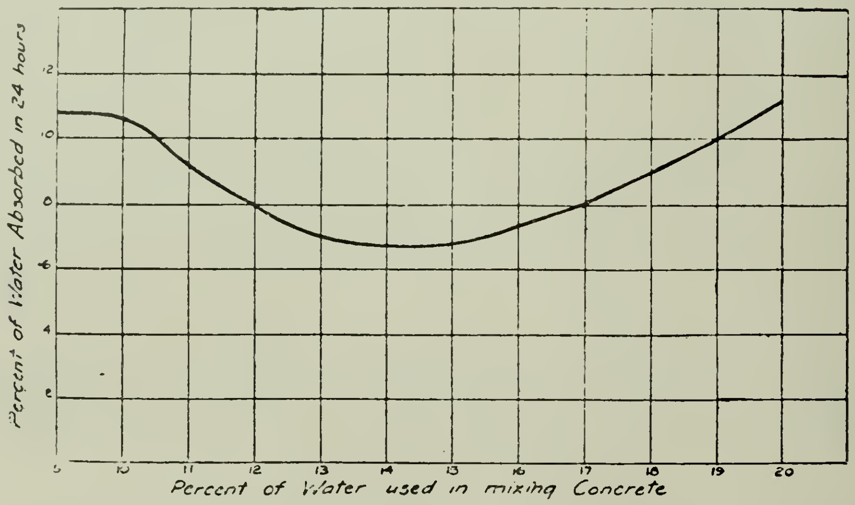


FIG. 2. DIAGRAM SHOWING AMOUNT OF ABSORPTION.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE RAFT SUPPORTING TOWER OF HOLY TRINITY CHURCH, KINGSWAY.

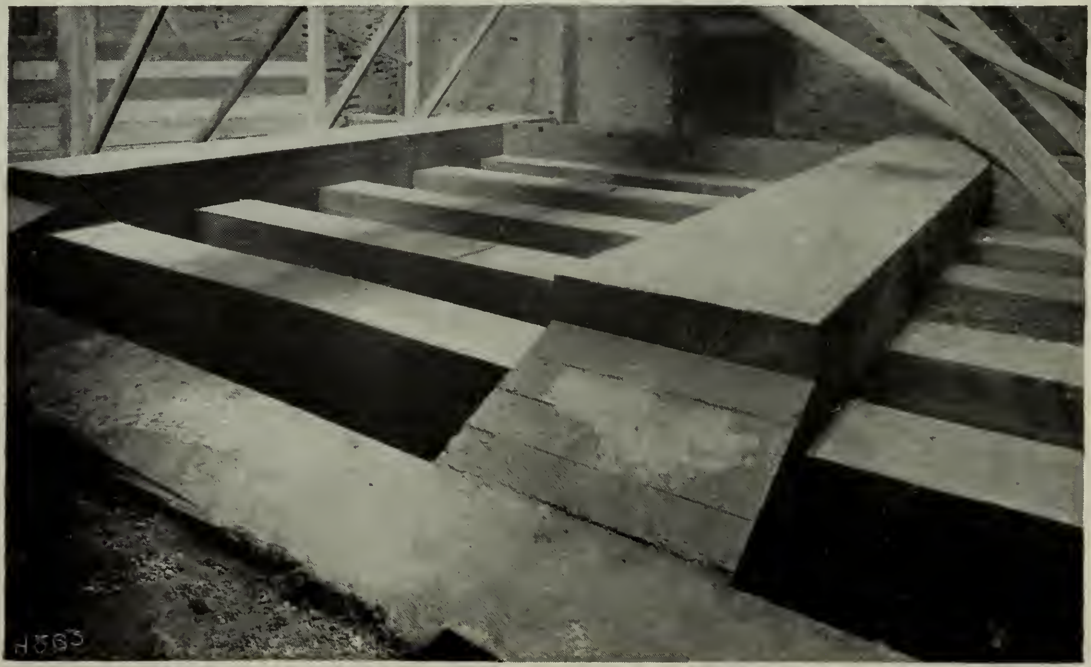
In connection with the rebuilding of Holy Trinity Church, Kingsway, a reinforced concrete raft was constructed to support the main tower.

The total weight of the church tower when completed will be about 2,500 tons, but at present this portion will not be carried beyond the level of the church roof, which represents a weight of about 1,200 tons.

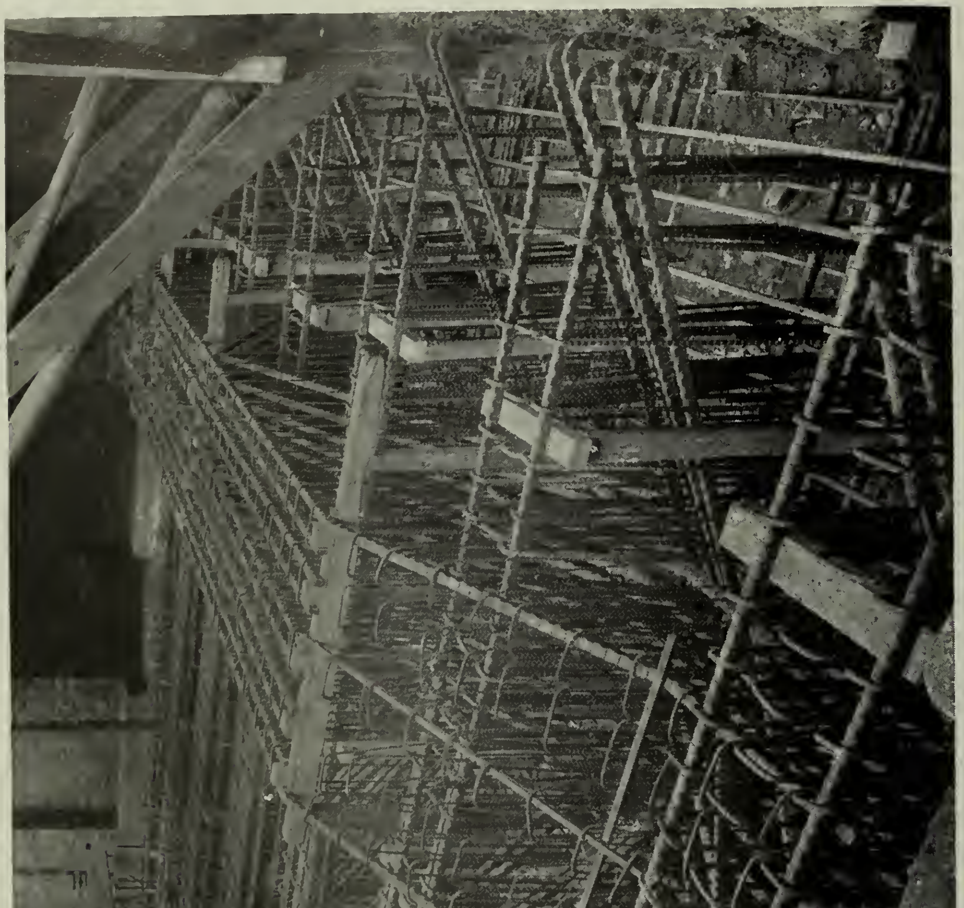
Owing to the settlement which must necessarily take place when the remaining 1,300 tons is added at some future date, the tower foundation has been designed to be entirely independent of that of the front or entrance portion of the church, or of the body of the church itself, and intentional lines of weakness are arranged on each side of the tower. Any such settlement of the tower will not interfere with the remainder of the building, and will then involve very slight repairs.

The reinforced concrete raft itself measures 30 ft. by 33 ft., and consists essentially of a lower slab supporting two main beams, on which the four corners and intermediate walls of the tower rest, the lower slab itself being stiffened by means of small cross-beams running between the main beams and beyond same to the edge of the slab. The slab is 12 in. thick, the two main beams on the top of the same are 4 ft. wide by 4 ft. 3 in. deep, and the seven cross-beams are 2 ft. wide by 2 ft. 9 in. deep.

The raft rests on an irregular bed of sand and gravel, and it was consequently



Reinforced Concrete Raft after Completion considered necessary to specially stiffen and strengthen this foundation to ensure a uniform spread of the load over the whole surface, and a uniform settlement.



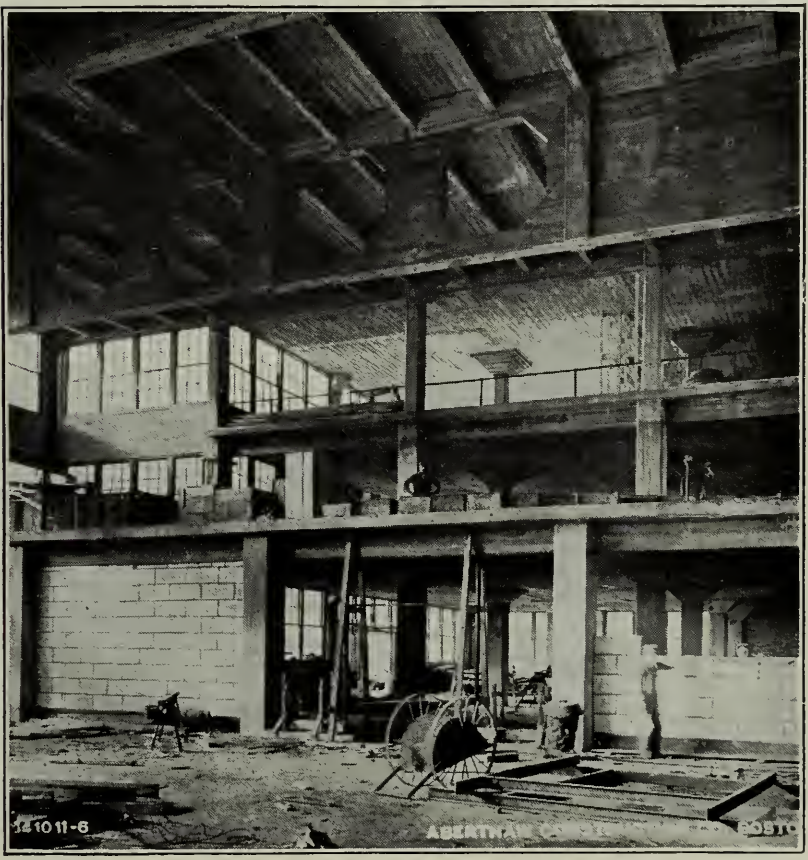
View showing Reinforcement in Position.
Reinforced Concrete Raft supporting Tower of Holy Trinity Church.

Patent indented steel bars were used throughout. The architects for the church are Messrs. John Belcher, R.A., and J. J. Joass; the consulting engineer, Alexander Drew, Esq., M.I.Mech.E.; and the contractors, Messrs. G. Godson & Sons, Kilburn, W.

AN EIGHTY-FOOT CONCRETE GIRDER.

A REINFORCED concrete warehouse which has recently been completed for the Hood Rubber Co. at East Watertown, Mass., contains a feature of design which is unusual from several points of view. This is a set of reinforced concrete roof girders which have a clear span of 80 ft. These immense girders span the crude storage room, which has a height of four stories, and is designed to be served by a crane loading and unloading the stored rubber on any of the various floors of the manufacturing section of the building. Along one side of the storage room are galleries, on the second and third floor levels in which machine work will be done.

The storeroom is 180 ft. long by 80 ft. wide, and by reason of the roof girders contains no columns whatever. The girders are 9 ft. 6 in. in depth, with a web 8 in. thick, and are designed to carry a flat concrete roof. Just below these trusses are a set of brackets formed on the concrete columns on either side of the storeroom for the support of the crane rail. This unusual construction was adopted as the ultimate solution of the problem of constructing a reinforced concrete building for warehouse purposes which may at some time in the future be changed over into an ordinary factory building. The entire design was perfected with an eye to this development and the future introduction of the usual concrete column and beam construction or mushroom floor construction throughout what is now the storeroom.

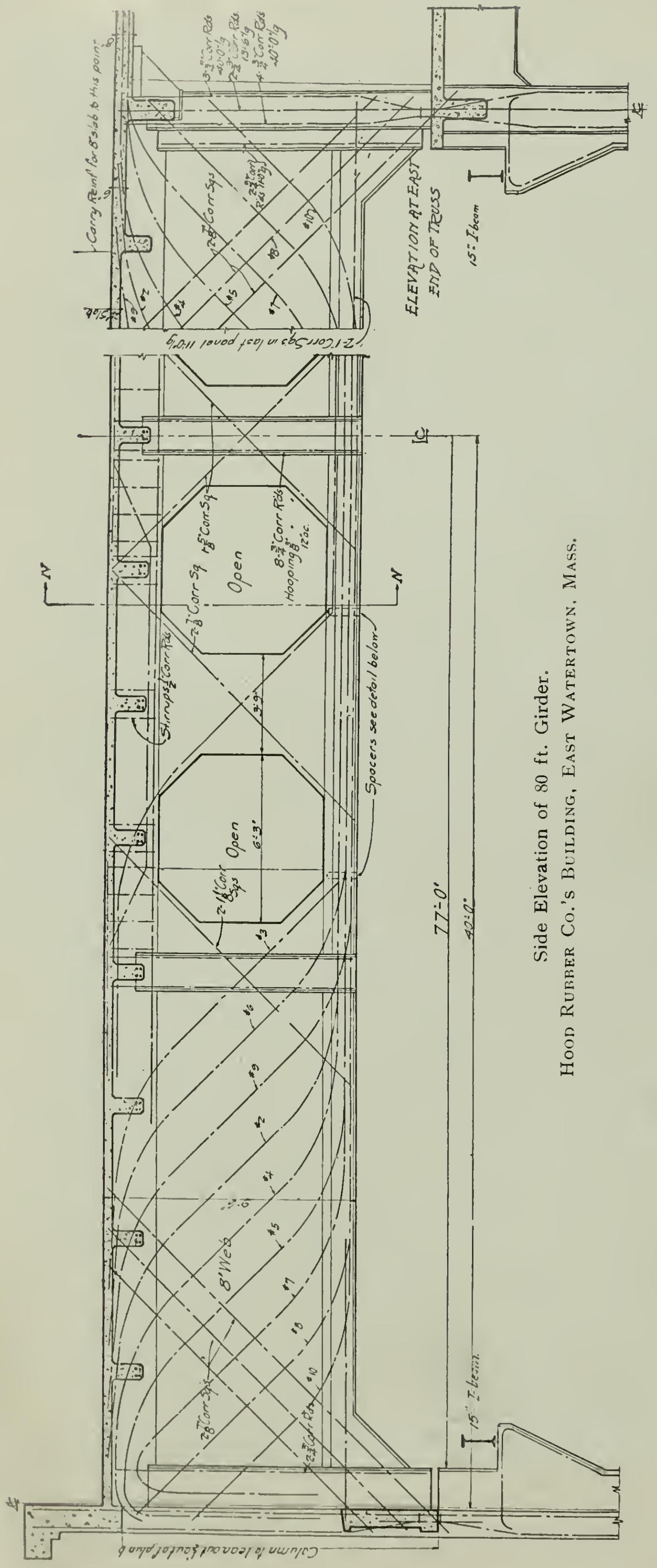


View of Interior.
HOOD RUBBER CO.'S BUILDING, EAST WATERTOWN, MASS.

Another future possibility which had to be considered in deciding upon the design was the addition of one, two, or three more stories. In case these changes are made a minimum of concrete need be removed from the girders to provide for columns, and it is expected that the storeroom may be transformed into an ordinary factory building at a minimum cost. The 80 ft. girders support 7 in by 18 in. longitudinal stringers, which are set 5 ft. on centres, and carry the 4 in. flat concrete roof slab.

The reinforcing for the long girders was designed by the designing engineer of the building, Mr. Henry F. Bryant, of Brookline, Mass., so that the stress should nowhere exceed 20,000 lb. per sq. in., and it is confidently predicted that there will be no serious deflection or stretch-cracks in spite of the unusual length of span.

As will be seen by a glance at the accompanying drawing of the reinforcement, the tension steel bars used are unusually long, the majority being about 100 ft. in length and $1\frac{1}{4}$ in. by $1\frac{1}{4}$ in. in section. Special work was required on the part of the rolling mill to get out these unusually lengthy reinforcing bars. The main tension reinforcement of these girders consists of ten $1\frac{1}{4}$-in. square bars, arranged as shown


ELEVATION AT EAST END OF TRUSS
15" I beam
Open
Open
6'3"
77'-0"
40'-0"
8" Web
Spacers see detail below
Stirrups ½" Corr Rds
2-1" Corr Sqs in last panel 11'0"lg
Corr. Reinf for Slab to this point

Side Elevation of 80 ft. Girder.
Hood Rubber Co.'s Building, East Watertown, Mass.

in the detail. For the diagonal reinforcement ⅝-in. corrugated square bars, arranged in pairs on either side of the centre, were used. Between the centre and either end the diagonal reinforcement consists of ⅞-in. and 1⅛-in. square bars. The end shear is taken by three ⅞-in. square corrugated bars, which are carried down diagonally, as shown in the drawing. Four 1¼-in. corrugated bars reinforced the roof stringers, and the roof slab is reinforced by ⅜-in. corrugated bars set diagonally 6 in. on centres. One-half in. corrugated bars were used in making up the stirrups. Considerable saving in total weight of the trusses has been accomplished by leaving hexagonal openings at various points not subject to stress. This procedure in no way impaired the strength of the girders, and at the same time made them considerably lighter. In the truss at the end of the building these spaces are utilised for windows. This truss carries a concrete block and brick cornice, and, being the end girder, its main tension reinforcement consists of seven instead of ten 1¼-in. bars, the lower flange being cut away on the outside to provide for a sill.

Naturally, in casting such girders as these, which are the longest ever designed in New England, unusual care had to be observed. Particularly was this true because of the fact that the entire building operations took place in mid-winter. Accordingly, the contractors, the Aberthaw Construction Co., of Boston, Mass., observed particular caution in mixing the concrete and insuring it against freezing. For the latter purpose a combination of the two usual methods of protecting concrete in winter — that is, by raising the temperature of the concrete, and, second, by lowering its freezing-point—was employed. A certain amount of salt was dissolved in the water used in order to lower the freezing-point, and at the same time the different constituents of the aggregate were heated by means of steam-pipes before going to the mixer. As an additional precaution the temperature of the entire building was maintained at about 30° above the outdoor temperature by enclosing the open spaces in the outer walls with sailcloth and burning coke in salamanders at various points in the structure. Holes were left in the forms at various points in the intermediate floors to ensure the rising of warm air to the upper stories in the manufacturing section of the building.

Alongside the spur track on which the carloads of cement, stone, and gravel were received a steam-pipe was run, with tees at various points. Steam hose connected to these tees was carried into the bottom of each stone-filled car, and thus the entire carload heated before going to the mixer. The sand, which was dug on the premises, after being screened was piled up over steam-pipes laid on the ground, and after being thoroughly warmed was carried to the mixer in a pit under the main floor at the centre of the building.

By pursuing the work through the cold weather it was possible for the Aberthaw Construction Co. to turn over the completed building to the owners four or five months earlier than could possibly have been the case if building operations had been postponed until the arrival of warm weather. Henry F. Bryant, of Brookline, Mass., was responsible for the entire design of this unique building, and had general supervision of its erection.

Reinforced Concrete Footbridge at Stockbridge, Mass.

A UNIQUE CONCRETE FOOTBRIDGE.

The use of reinforced concrete for light construction work of considerable proportions is exemplified by the unique and artistic footbridge erected over the Housatonic River at Stockbridge, Mass.

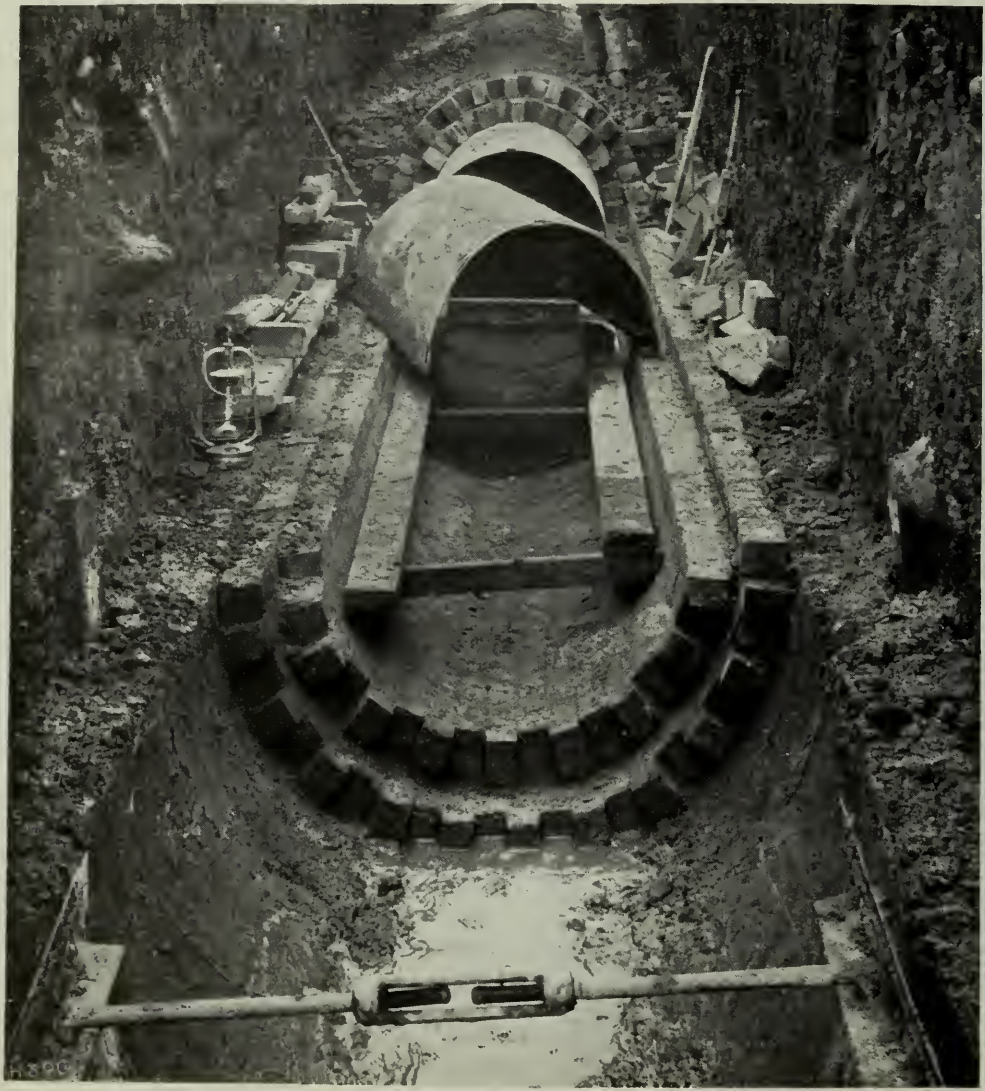
This bridge has a clear span of 100 ft. in length, with a rise of only 10 ft. The width of the bridge is 7 ft. 6 in. The arch is 7 in. thick at the crown, and is reinforced with 7-in. I-beams. The bridge successfully withstood a test load of 25 tons at the centre before it was opened to the public. We are indebted to the *Concrete Age* for our illustration.

COMBINED BRICK AND CONCRETE CULVERT AT BLYTH.

The combined brick and concrete culvert at Blyth is of 3 ft. internal diameter, 1,800 ft. long, formed of two rings of brickwork, and surrounded with concrete, The culvert is included in a contract for certain bridges, etc., let by the North-Eastern Railway Co. to Mr. T. Telford Gibb, contractor, of Westminster, and will be handed over to the Blyth Urban District Council on completion. The Blaw system of collapsible steel centering was used in this work.

Steel centres in segments of 5 ft. in length were used for forming the concrete invert 4 ft. 6 in. in diameter, and for the top half of the brickwork centres, 3 ft. in diameter, the centering was set in lengths of 50 ft. at a time.

The excavation being down to the full depth, 9 in. of concrete was deposited in the trench, bringing it up to the level of the bottom of the invert ; then the 4 ft. 6 in. centres were placed on the top of this, being held in position and prevented from rising by timber placed at intervals over the top and wedged against the sides of the trench. The concrete was rammed in round the centres and allowed to set, and the centres then removed. The brickwork for the bottom half of the culvert was then built, and on the top of this the 3-ft. diameter centres were placed, and the upper half of the culvert brickwork built on these. Thereupon the remaining concrete was formed on the top of the brickwork.



Combined Brick and Concrete Sewer, Blyth.

The steel centres were withdrawn by tightening the union nuts, which withdrew the centres from the formed brickwork or concrete ; the union nuts were then loosened and removed with the rods, and the centres were drawn forward ; then the rods were replaced and tightened up, and the centres were then ready for further use. The centres made a very smooth and perfect surface on the concrete and joints of the brickwork, and, excepting brushing, have not needed to be cleaned or repaired in any way. This Blaw system of centering was used for the culverts in connection with the Panama Canal locks at Gatun, described in our May issue.

CRASTER PIER AND HARBOUR WORKS.

Reinforced concrete was used throughout the construction of both the piers at Craster Harbour, which was formed by excavating the solid basalt in which the place abounds.

The harbour has a water area of about 1¾ acres, with a depth of 14½ ft. at high water. The north pier is 170 ft. long, the south pier 190 ft., and the west quay is 210 ft. long.

Concrete Piers at Craster Harbour.

The concrete was mixed in the proportions of 1 part Portland cement, 2 parts sand, and 3 parts crushed whinstone, the sand and whinstone being obtained on the spot.

In the last section of the south pier reinforced concrete piles were required, and Messrs. Brims & Co., of Newcastle, undertook this. They attempted to drive these reinforced concrete piles while afloat, working from a lighter, but as the seas were so heavy that method of driving had to be abandoned, and a cantilever staging was erected, from which the piles were placed and driven. Very large and troublesome boulders were encountered throughout the whole of this undertaking, but although this method of driving the piles was a very rare one, it has succeeded admirably, and the construction of the harbour is most successful. Messrs. McLaren & Frowde, Ltd., were contractors for the rest of the reinforced concrete work. Messrs. Sandiman & Son, of Newcastle, were the architects for the whole undertaking.

HALL OF RECORDS OF REINFORCED CONCRETE.

Experience of the past few years has demonstrated the fact that reinforced concrete is the ideal construction where immunity from fire risks is the chief consideration. This was the main factor that influenced the authorities of Kern County, Bakersfield, California, when they decided to build the Hall of Records of that material. Messrs. Train & Williams, of Los Angelos, were the architects for the construction.

The building is of one story and a basement, covering an area of 94 ft. by 106 ft., and is absolutely fireproof, the walls, floors, and ceiling being of reinforced concrete. The main feature of the building consists of a recorders' room, 80 ft. sq. inside measurement, 20 ft. high between floor and ceiling, with four circular reinforced concrete columns in the centre, 27 ft. apart (equal distance), supporting a concrete, galvanised steel and wire glass dome 22 ft. in diameter.

Hall of Records, Bakersfield, Cal.

The main floor, ceiling, and roof construction is of concrete beams and girders between the four columns and the wall piers in the following manner, four beams of 27 ft. span being framed into girders of the same span, each being reinforced with four bars bent into truss form. The panels between beams are of 7½ ft. span, being 3 in. to 6 in. thick, reinforced with bars or rods in both directions.

The columns are reinforced with round rods, and the piers, flat, from 6 ft. to 8 ft. square, are reinforced in the bottom footing only, with rods in both directions. Concrete used was in the proportion of 1 to 5.

The exterior is of the Italian Renaissance style, with Ionic detail for capitals, bases, courses, architraves, and ornaments rendered in pressed brick, artificial cement stone, and cement ornament and wire glass.

The front portico circular columns are cast cement reinforced, cast in wood moulds carefully made to proper size and entasis.

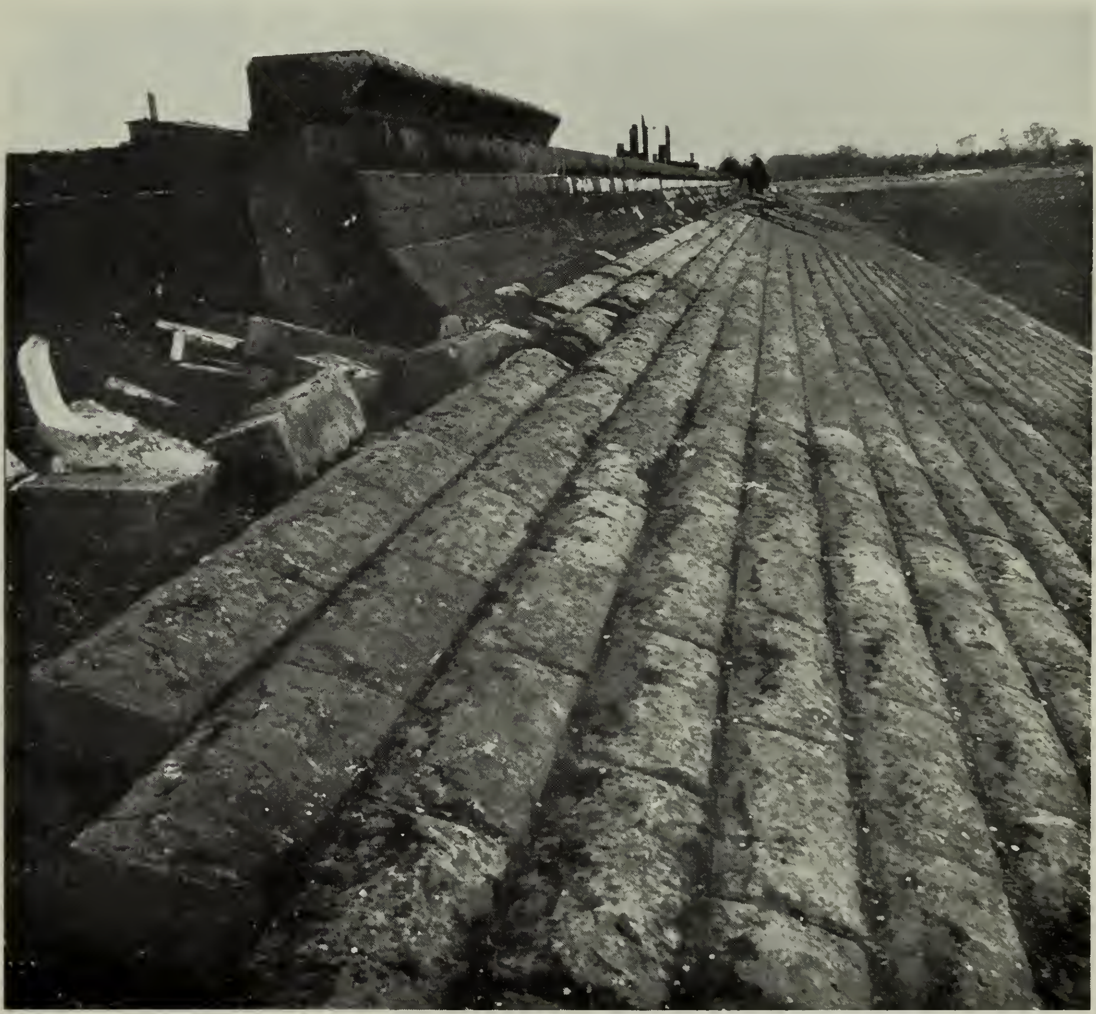
The main room, foyer, private office, portico, and lavatories, etc., are floored with cement and American encaustic tile (mosaic) in patterns.

The basement proper is 36 ft. by 75 ft., and is approached from the rear outside and from the side entrance on first floor by means of reinforced concrete stairs.

THE ISLAND BARN RESERVOIR.

In our last issue we gave some interesting particulars of the Island Barn Reservoir. As it was quite a new departure to line a reservoir of such a great size with concrete blocks, we are now giving a further illustration which shows in more detail the great extent of the work.

Altogether for this contract 100,000 " Winget " rock-faced concrete blocks were used, each block being 32 in. by 8 in. by 8 in. solid. The contractors for the work were Messrs. Robert McAlpine & Sons, of London and Glasgow, who used four " Winget " machines. The guaranteed output per day for each machine is 200 blocks, but owing to the speed organisation of the contractors, and increased gang of men, the average output on this work was over 400 blocks per day. To produce these 100,000 blocks nearly 1,500 tons of cement were used, and this was supplied by the Associated Portland Cement Manufacturers (1900), Ltd.



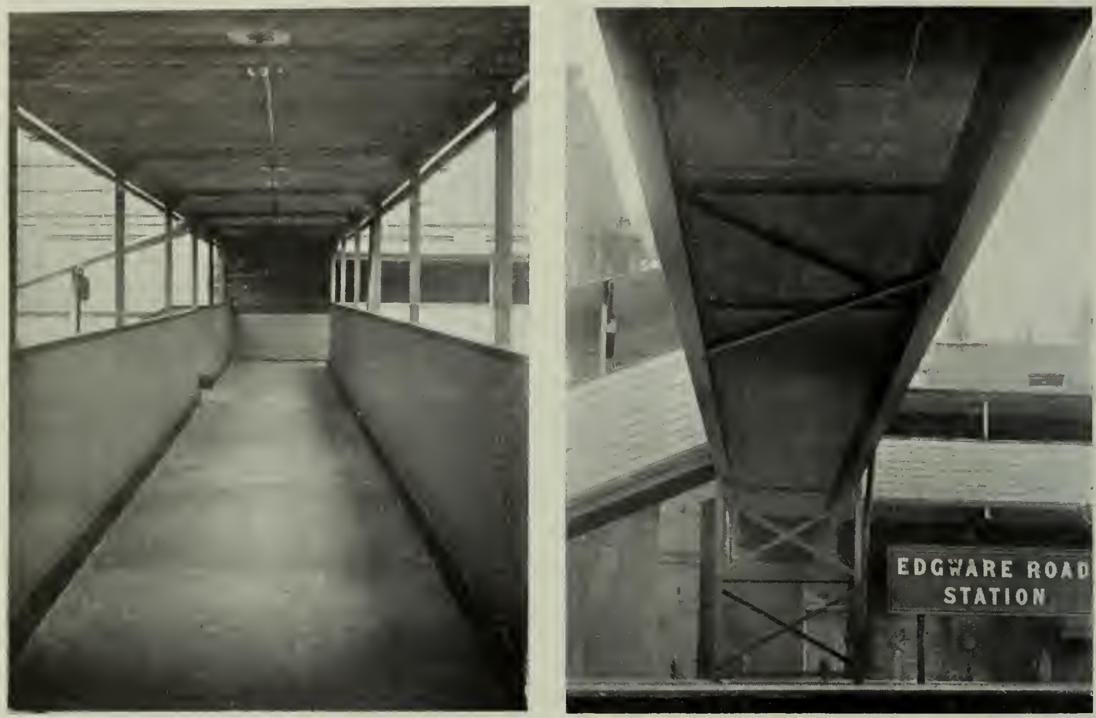
Concrete Block Lining to the Island Barn Reservoir.

NEW ENTRANCE TO EDGWARE ROAD STATION.

The new entrance to Edgware Road Station, on the Metropolitan Railway, consists of a booking hall and office at street level, carried on steel joists over the company's lines, a gallery carried on steel joist cantilevers leading from booking office to the up-platform, and a steel joist footbridge continuing the gallery to the down-platform.

The new booking office fronts on to Marylebone Road, and forms a direct entrance to the present station. The floors of booking office, gallery, and footbridge are all carried out in reinforced concrete. The concrete was mixed in proportion 3 : 2 : 1, the aggregate being screened gravel and sharp sand.

The spans and sizes of bars are given in the table below. All the bars have been supplied by the Patent Indented Steel Bar Co., and are their standard square section bars of steel having an elastic limit of 22 tons.



REINFORCED CONCRETE FOOTBRIDGE, EDGWARE ROAD STATION.

The top $\frac{1}{4}$ in. of concrete is finished, whilst still green, with Labour's patent paving.

	Span	Thickness	Span Bars	Tie Bars
Booking Hall	11 ft. 6 in.	5 in.	$\frac{1}{2}$-in. bars, 6 in. centres	$\frac{1}{2}$-in. bars, 2 ft. centre
Gallery	11 ft. 0 in.	4 in.	$\frac{1}{2}$-in. ,, $7\frac{3}{4}$ in. ,,	2-in. ,, 2 ft. ,,
Footbridge	6 ft. 6 in.	3 in.	,, 5 in. ,,	,, 2 ft. ,,

The engineer to the Metropolitan Railway is Mr. W. Willox, M.Inst C.E.

BOOKING HALL AT EDGWARE ROAD STATION.

NEW USES FOR CONCRETE
AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork where structures of great height are required.—ED.

CONCRETE SLAB DWELLINGS.

THE system of construction described in this article, particulars of which are taken from the *Cement Age*, was the outcome of a special study of the design of model dwellings in order to reduce their cost, and at the same time to secure absolutely fireproof construction.

Mr. G. Atterbury, F.A.I.A., who had devoted considerable time to this question, and had studied the various methods in use in Europe and America, came to the conclusion that the solution of the problem lay in the standardisation not only of the general plan, but of its various units and structural elements, combined with proper organisation of the work of erection. He prepared a tentative programme for the construction of concrete tenements for the Russell Sage Foundation, which is a fund created by Mrs. Sage, of New York, to provide for " the improvement of social and living conditions " among the poorer classes.

A series of studies in economic construction was undertaken with the following objects :

1. To study and compare the various constructional systems, in use or proposed, that offer any promise of the desired economic results.
2. In connection with this to determine the feasibility of a unit system of design, and the extent and the types of building to which standardisation may be successfully applied, provided the preliminary experiments go to show the economy and feasibility of a standardised and ready-made dwelling house.
3. To devise and conduct certain experiments as to new methods of construction, and to make a demonstration of the commercial and philanthropic value of the results thereof, if such results should appear to justify the necessary expenditure.
4. To undertake a special study of concrete construction, inasmuch as the use of some form of cement construction appears to offer the most promising field for radical saving in cost, and especially in view of the results of my own preliminary studies and experiments.

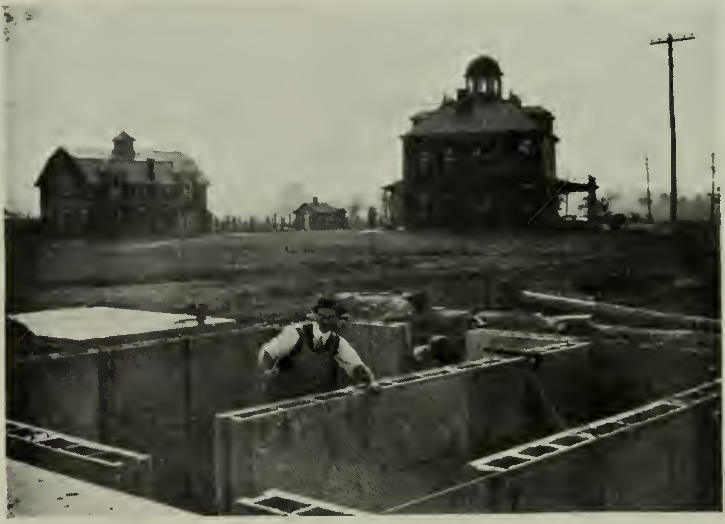


FIG. 1. SETTING BASEMENT WALLS.

The results of the studies showed that the theoretic solution of the problem must consist of " the employment of a more or less standardised shop-made and completely finished building section or unit of the maximum economic size."

The practical solution of the problem is given in the account below of one of the Sage Foundation Houses, which was designed by Mr. Atterbury, and although built primarily as an experiment, it has been occupied for some time with entire satisfaction to its tenants.

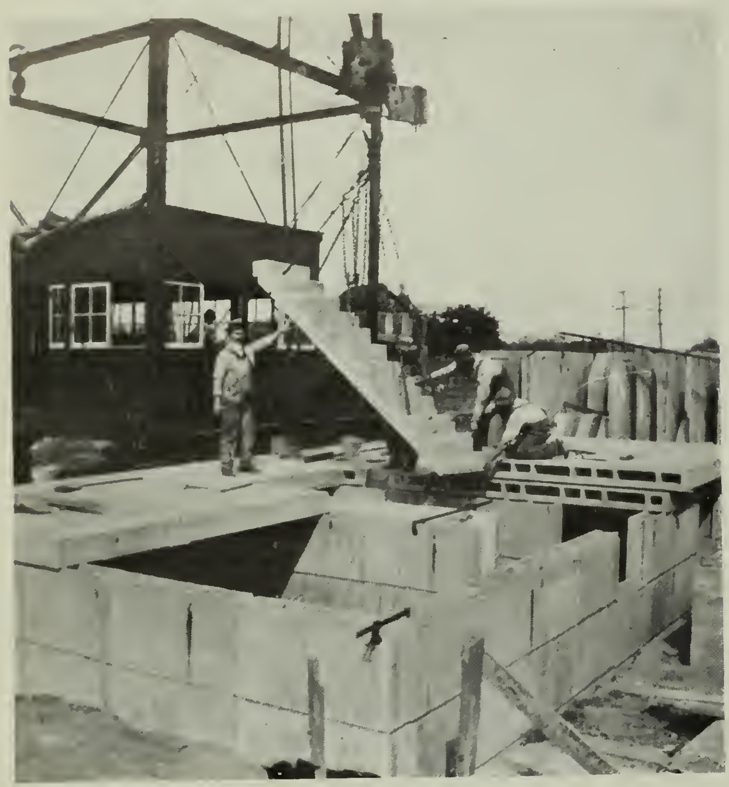


Fig. 2. Setting Basement Stairs.

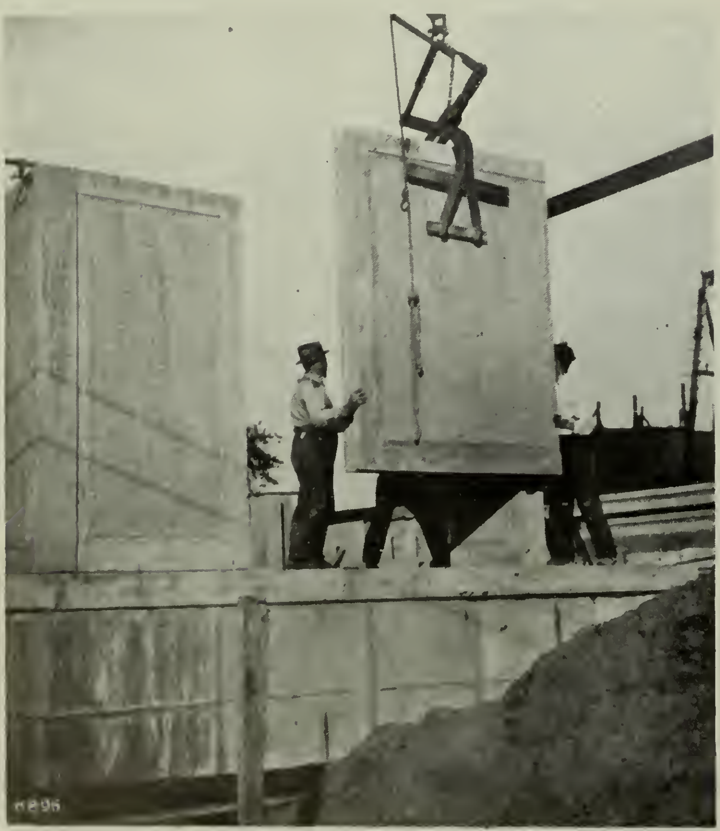


Fig. 3. Setting a Wall Block.

The house has a floor area of 18 ft. by 28½ ft., and is built of 170 separate blocks, consisting of 101 wall window panels, door heads, and chimney blocks, 20 floor blocks, 12 roof blocks, and 37 partition blocks.

The process of construction will be seen from our illustrations.

Some of the houses are plastered inside direct on the sectional concrete slabs, and the floors are also top-dressed with mortar after the slabs are in position; but in the house in our illustration no plastering was used, the slabs being of such smooth finish as to render this unnecessary.

The sectional blocks of the basement walls are set direct on the floor, forming the basement as shown in *Fig.* 1. These blocks are 3 ft. 9 in. wide, 8 ft. high, and 9 in. thick. They consist of hollow tubular sections, tongued and grooved together, the joint between the block and the floor being grouted perfectly tight after being set in place. These wall blocks are of hollow sectional construction.

The first-floor blocks are then laid in place, being bedded in mortar directly on top of the wall blocks. These bind the walls together, there being no horizontal joints in bearing walls intermediate between the floor levels. The floor blocks are 8 in. thick, the largest being 9 ft. by 11 ft., and weighing about 2¾ tons each.

The stairs are cast in one piece, and set as is shown in *Fig.* 2.

Fig. 3 shows the setting of a block of the first-story walls, showing the finish of the outside surface, and the lifting tongs. These blocks are mostly 6 ft. wide, 8 ft. high, and 9 in. thick, and weigh about $1\frac{1}{4}$ tons each.

Fig. 4 shows the setting of the first block of the second-story floor, showing also the method of lifting the blocks by chains fastened into lewis holes near the edges of the blocks, where the holes will be subsequently covered by the wall blocks.

Fig. 6 shows the erection of the second-story walls, and *Fig.* 5 the erection of the roof gables; this figure also shows very clearly the comparative size of the tower erecting crane, which has an arm extending over and far above the entire house, so that any block can be taken from the storage pile and set in exact position by simply swinging the arm.

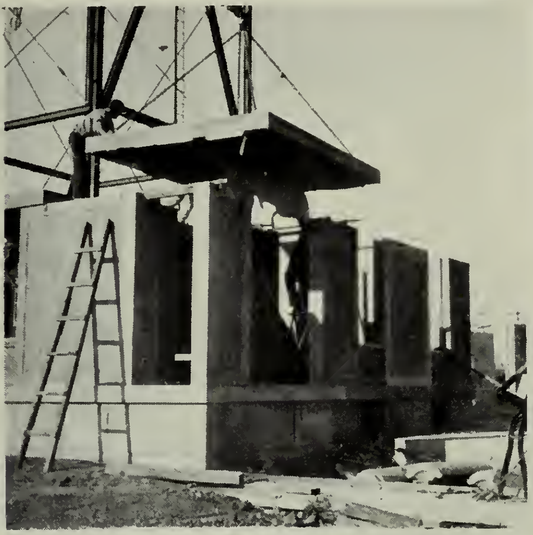


FIG. 4. SETTING A SECOND-FLOOR BLOCK.

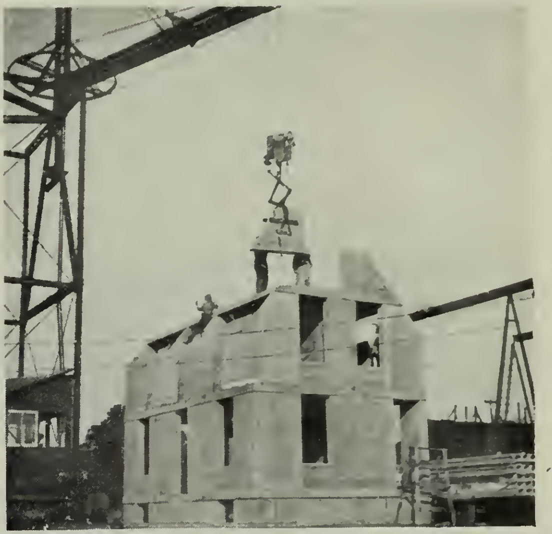


FIG. 5. ERECTING ROOF GABLES.

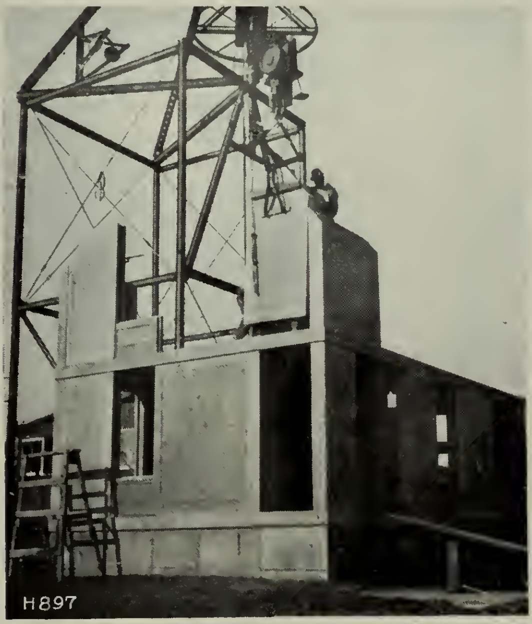


FIG. 6. ERECTING SECOND-STORY WALLS.

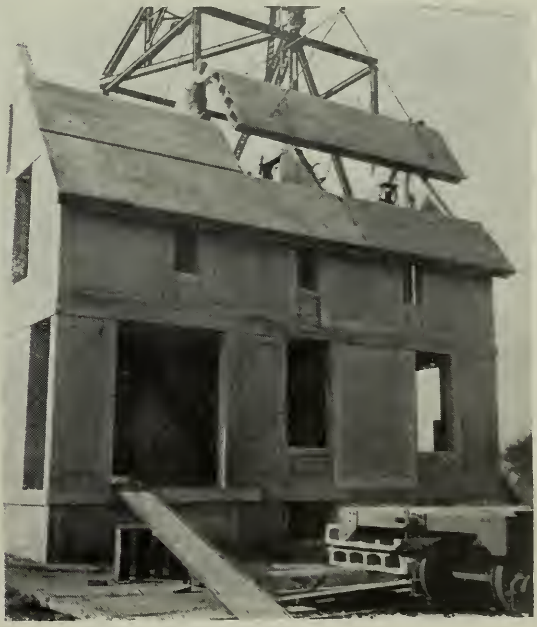


FIG. 7. PLACING THE ROOF BLOCKS.

Fig. 7 shows the placing of the roof block, the largest of these blocks being 5 ft. 6 in. thick, and weighing about 3 tons. The blocks are made with an overlapping joint similar to the overlay of tile, and form a water-tight roof.

The house has a floor area of 18 ft. by $28\frac{1}{2}$ ft., and is built of 170 separate blocks, consisting of 101 wall window panels, door heads, and chimney blocks, 20 floor blocks, 12 roof blocks, and 37 partition blocks.

As is seen by the above example, the Atterbury sectional construction consists of moulding large hollow blocks, using as many blocks of one size as is consistent with the design. After these blocks are moulded and hardened, they are transported to the site of the building and erected by the use of a power crane. The whole process is simple, very rapid, and requires only a small amount of labour.

Material.—In all of this work the concrete used consists of a good grade of Portland cement, clean, sharp, well-graded sand, the ordinary proportions being 1 volume of cement, 2 of sand, 2 of gritts, and 2 of gravel. These materials are well mixed with water to a thin paste and poured into the moulds.

Moulds.—The present moulds for wall blocks can be opened or closed in less than two minutes, and allow of the casting of a block up to 6 ft. wide, 10 ft. high, and 3 in. to 18 in. thick, in about 15 minutes, and the removal of this block from the mould and cores within 8 or 10 hours afterwards and set in storage.

Finish.—The forms are all constructed of steel, which gives a smooth, glossy finish to the concrete. For outside work this smooth finish is left as a border, and a panel formed by running the other part with a wire brush to expose the gravel aggregate.

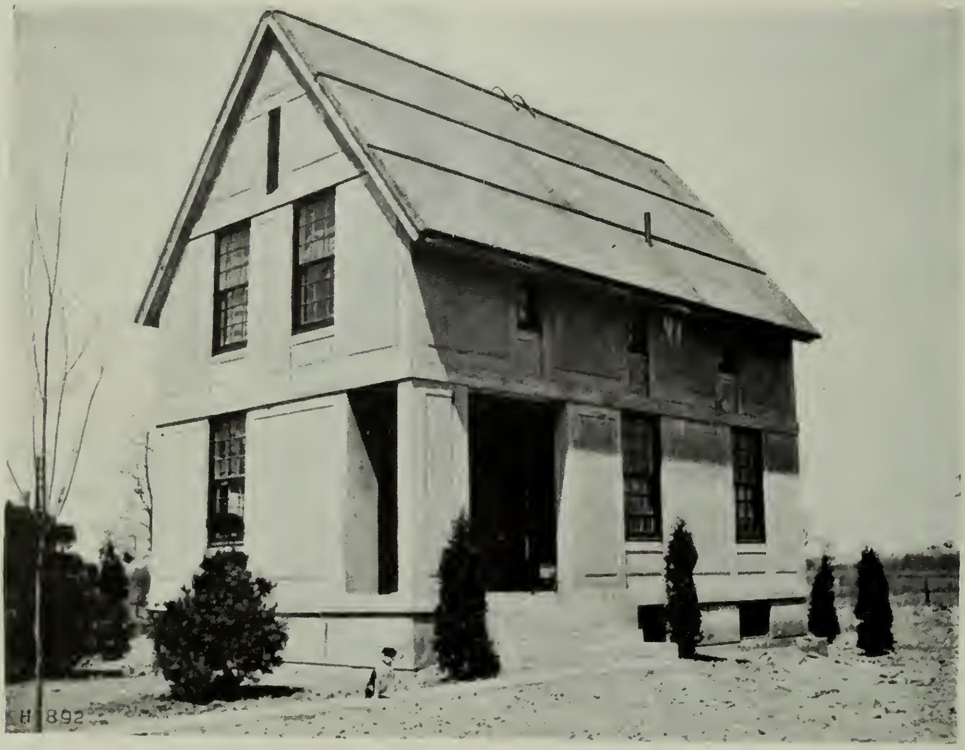


Fig. 8. View of Finished Dwelling.

Floor Blocks.—Floor and roof blocks are cast flat, as it is more convenient to properly place the steel reinforcement and to trowel down the exposed surface to a smooth, hard sidewalk finish. A frame is first set up, the reinforcement placed, and the cores all lowered into place at once; the concrete is then placed, and the upper surface coloured to suit and trowelled smooth. When the concrete is sufficiently hardened, the cores and frame are removed and reset above, and the blocks built one on top of the other until a high pile is constructed.

Joints.—The joints between wall blocks are formed by a tongue and groove, the tongue fitting loosely, or by two grooves and a spline.

After setting the blocks this joint is run full of 1 to 2 mortar, making everything solid and water-tight.

Erection.—The blocks are erected by a travelling crane. This crane is operated by electricity, and has a capacity of 5 tons and a radius of action sufficient to cover two houses at once, or by moving longitudinally, it can work on any number of houses in a row.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"Notes on Irrigation Works." By N. F. MacKenzie, Hon.M.A., M.Inst.C.E.

London: Constable & Co., Ltd., 10 Orange Street. Leicester Square, W.C. Price 7/6 net. Demy 8vo, 112 pp. + viii.

Contents.—Introductory—Statistics Required for Preparing an Irrigation Project—Types of Weirs—The Development of Irrigation in Egypt since 1884—On the Design of Irrigation Channels—Irrigation Revenue and Land Revenue in India.

The subject of irrigation is, of course, of foremost importance in India and Egypt, and it is becoming of immense importance to other countries—in particular, North America and South Africa. There have been a fair number of large treatises on the subject published of recent years, but we are very glad to welcome this little book, which forms a most interesting and admirable introduction to the subject generally. The book consists of lectures addressed to students of engineering and of geography, and delivered under the auspices of the Common Fund of Oxford University in the winter of 1909. The author was until lately Under-Secretary for Irrigation to the Government of India, and he is a master of his subject.

The author refers to the great irrigation works of ancient Chaldea and Assyria, and Colorado and Arizona; the former of which may shortly be restored by Sir William Willcocks—the effect of which on the world's grain markets cannot as yet be gauged. With such examples before us we gain some idea of the great province of the irrigation engineer, and the immense possibilities of the extension of irrigation works throughout the world. In great part the chief engineering works of the future will be in irrigation, and, with growth of population, the fabric of future civilisation will depend upon them. The generally accepted classification of irrigation works is: (1) canals, (2) tanks or lakes, (3) wells, (4) drainage works.

In the construction of all these concrete has a large share; and though we could not expect in such short compass that the author could deal in detail with the design of irrigation works, we find that he has dealt surprisingly fully with certain aspects, and has thrown out many suggestions and hints to lead the student further which will well repay study.

"Popular Handbook for Cement and Concrete Users." By Myron H. Lewis and Albert H. Chandler.

New York: Norman W. Henley Publishing Co., 132 Nassau Street. Price 10/-. 8vo, 430 pp. + x.

Contents. — Introductory — Kinds of Cement, and How They Are Made—Properties, Testing and Requirements of Hydraulic Cements—Concrete and its Properties—Sand, Broken Stone and Gravel for Concrete — How to Proportion the Materials—How to Mix and Place Concrete—Forms for Concrete Construction—The Architectural and Artistic Possibilities of Concrete—Concrete Residences — Mortars, Plasters and Stuccos, and How to Use Them—The Artistic Treatment of Concrete Surfaces — Concrete Building Blocks—The Making of Ornamental Concrete — Concrete Pipes, Fence Posts, etc.—Essential Features and Advantages of Reinforced Concrete—How to Design Reinforced-Concrete Beams, Slabs and Columns—Explanation of the Theory of the Design of Reinforced-Concrete Beams and Slabs—Systems of Reinforcement Employed—Reinforced Concrete in Factory and General Building Construction — Concrete in Foundation Work—Concrete Retaining Walls, Abutments and Bulkheads — Concrete Arches and Arched Bridges—Concrete Beam and Girder Bridges—Concrete in Sewerage and Drainage Works—Concrete Tanks, Dams and Reservoirs — Concrete Sidewalks, Curbs and Pavements—Concrete in Railroad Construction—The Utility of Concrete on the Farm—The Waterproofing of Concrete Structures—Grout or "Liquid Concrete," and Its Uses — Inspection of Concrete Work—A Summary of Essential Rules and Principles of Construction for Securing Good Concrete Work—Cost of Concrete Work.

This book has much the same object as that book entitled "Everyday Uses of Portland Cement," issued by the Associated Portland Cement Manufacturers, Ltd., and it is fated to be forestalled by that work, at a cheaper price, too. It contains a good deal of information on various branches of the subject, as the foregoing summary of contents goes to show. Little of that information is, however, original, being reprinted from American catalogues, papers and reports issued from time to time—some of which are out-of-date, and all of which might be collected, without much expense, by anyone industrious enough to do it, when he would find himself in possession of a more complete set of documents. The book contains a great deal of useful information—we do not gainsay it—but it is neither happily-enough presented, nor does it contain sufficient original information to lead us to view its production with any enthusiasm. Its practical part is often skimpy and effete, while the theoretical information, on both cement and plain concrete, is often in error; while in the matter of reinforced concrete, it seems to us too amateurish, and of little use to the student or designer.

THE PRACTICAL CONCRETE WORKER

"Ornamental Concrete Without Molds." By A. A. Houghton.

8vo, 122 pp. Price 8/-.

"Concrete from Sand Molds." By A. A. Houghton.

8vo, 146 pp. Price 8/-.

"Concrete Workers' Reference Books." By A. A. Houghton.

8vo, about 60 pp. Price 2/- each.

No. 1. Concrete Wall Forms.
No. 2. Concrete Floors and Sidewalks.
No. 3 Practical Silo Construction.
No. 4. Molding Concrete Chimneys, Slate and Roof-Tiles.
No. 5. Molding and Curing Ornamental Concrete.
No. 6. Concrete Monuments, Mausoleums, and Burial Vaults.

New York: Norman W. Henley Publishing Co., 132 Nassau Street.

The practical worker in most arts and sciences has preceded the theoretician, and in concrete we see no exception. The practician early took to concrete as a most useful material, and he has shown many possibilities inherent in the material which he has often applied in ways that were looked at as unfitting until success was achieved. There are plenty of theoretical treatises, but they do not as a rule touch the practical worker, who is so very important in the cement industry. We therefore are pleased to see his wants so well catered for by Mr. A. A. Houghton. Much of the information conveyed in these volumes is certainly not new, nor is it always stated in the way we should have wished, but undoubtedly the books possess considerable value to the practical worker, for in addition to explaining the way in which to manufacture the concrete, they tell him how to make the moulds, and set out the architectural forms (some of these again are crude, and, to our thinking, unsuitable for concrete, though we must admit they are favoured by many, and therefore the books only rightly give the information desired). The books of most interest and value are the two first named. The method of executing concrete "without moulds" is to employ a running mould like a plasterer uses for executing work in his special material. Concrete requires somewhat different handling, however, as it is rougher in texture and less plastic. The casting of concrete in moulds of sand is an old process, but certainly we do not know of any other book on the subject. The sand is made to cohere by the admixture of glutinous substances, and can be made hard to stand ramming, or soft and absorbent. Both these books deal with processes of manufacture which are economical, and, moreover, they have distinct merits of their own in regard to texture. We commend the books to those who desire practical instruction in concrete-making

CORRESPONDENCE.

Under this heading we invite correspondence.

LONDON, *July 20th*, 1911.

SIR,—Referring to your reviewer's reply to my letter published in your current issue, I challenged him to point out a single instance in which my ready reckoners give a different result from that obtained by the use of formulæ.

While the absurdity of his example is obvious to the specialist, it is more than likely that it will still further confuse the ordinary practitioner, and I feel it my duty to point out the erroneous conclusions he comes to.

To start with, he puts the cart before the horse. Nobody can possibly design a ribbed floor without ascertaining the thickness of slab first, as the depth of the T is entirely dependent on this. The thickness of the slab, again, depends on the load to be carried, and the distance between the beams. There can consequently be no question of *If* the slab is 10 in., or *If* the slab is 3 in.

Incidentally, your reviewer has proved the correctness of the reckoners by stating that if he adopts a 10-in. slab he gets precisely the stresses the reckoners are based on.

In the booklet supplied with the reckoners I clearly state that it is most economical to make the distance of beams equal to one-third of the span. This being 48 ft. in his example, the span of slab would be 16 ft.

I cannot imagine how your reviewer can possibly suppose anyone to be foolish enough, or inexperienced enough, to design a 3-in. slab for a 16-ft. span, as such a slab would, of course, not support its own weight; nor, on the other hand, do I believe that there is a man in our profession who is likely to space heavy beams of 48-ft. spans 3 ft. 9 in. centre to centre. But supposing a designer did so, it stands to reason that the total load would only be about one-third of the load your reviewer takes in the first part of his example, owing to the reduction in the dead load and live load. Furthermore, the depth and reinforcement of a beam carrying a 3-in. slab for a 3 ft. 9 in. span requires naturally an entirely different area as the same is required for a 16-ft. span and a 10-in. slab.

Incidentally, I may remark that I clearly state that no slab should be less than 3½ in. thick; and, furthermore, no designer would carry out such a floor as your reviewer states; he would, of course, adopt subsidiary beams.

However, supposing someone *did* select such a foolish policy and space beams of 48-ft. span 3 ft. 9 in. apart. Your reviewer's example apparently works out at a total loss of 275 lb./ft.^{2}, which, after deducting the dead loss of slab and rib, would leave a live load of 145 lb./ft.^{2} Now, adding the dead load of a 3-in. slab and rib, which come to $38+10=48$ lb., we should require resistance to a total load of, say, 190 lb./ft.^{2}, thus basing the loading of the thin slab on precisely the same footing as his thick slab. The load on the rib or the T would then be $190\times 3{\cdot}75=712{\cdot}5$ lb. per foot run. Reckoner 4 gives us for this figure and for a 48-ft. span, a, $d=12$ in., and an $A_T=0{\cdot}92\times 16=14{\cdot}72$ in.^{2}

Checking these values by the R.I.B.A. formulæ we get

$$p=\frac{14{\cdot}72}{144}=0{\cdot}1 \qquad Z=\frac{Kd}{3}=1{\cdot}47 \text{ in.}$$

$$Kd=\frac{192\times 3^2+2\times 14{\cdot}72\times 15\times 12}{2\times 192\times 3+2\times 14{\cdot}72\times 15}=4{\cdot}4 \text{ in.} \qquad M=\frac{190\times 3{\cdot}75\times 48\times 48\times 12}{8}=2462400$$

Consequently

$$t=\frac{2462400}{14{\cdot}72(12-1{\cdot}47)}=15886 \text{ lb./in.}^2$$

$$c=\frac{2\times 2462400\times 4{\cdot}4}{192\times 3(2\times 4{\cdot}4-3)(12-1{\cdot}47)}=615 \text{ lb./in.}^2$$

and I contend that no sensible person can call these results incorrect.

As to the other points raised, I have already explained that these are quite elastic, and various values and details are adopted in various countries where reinforced concrete is used. In my publications I have always adopted what seemed to me the happy medium taken from the methods of the various countries, and I shall continue to do so in future. I daresay every specialist has his views; and, after all, considering the factors of safety adopted, these little variations do not count much in actual practice.

I again challenge your reviewer to prove his case by an example, and by such example I mean something that is intelligible to the ordinary practitioner, such, for instance as: a floor to be constructed with T-beams of such and such a span to carry such and such a load per ft. super, etc., etc.

If your reviewer can prove by an example that he gets a different result when using my reckoners than when using the R.S.B.A. formulæ he must, indeed, be a conjurer, considering that the reckoners are based on precisely the very formulæ he uses to prove them wrong, and he is consequently attempting the impossible.

If he cannot do so I must again call upon him to withdraw, and make such amends as I am entitled to. F. RINGS.

The Editor, CONCRETE AND CONSTRUCTIONAL ENGINEERING.

Our Reviewer's reply to the above.

I am sorry that my previous attempts have been insufficient to convince Mr. Rings.

He now makes certain further statements which appear to me to show that he has not viewed my remarks in the proper way; and to infer that I meant what I did not say.

I did not say that one could "design a ribbed floor without ascertaining the thickness of slab first." I merely started off at the point where one had ascertained a distributed load on a beam of a certain span—*i.e.*, at the point at which Mr. Rings' T-beam calculator is to be used. Let it here be noted that Mr. Rings talks now of ribbed "floors"; in his booklet he speaks of ribbed "ceilings." My example is of a T-beam in general, and will apply to ribbed ceilings, which are often constructed of reinforced concrete 3 in. thick, which thickness is sufficient for continuous 16-ft. spans when only sustaining their own load. But, be it observed, a distributed load can be obtained on the beam without its coming directly from the slab that forms the table of the T. In the case of a ceiling, it may come from a dwarf wall sustaining a roof over. Therefore my reference to 3 in. was quite a practical case.

Again, I did not say that beams of 48-ft. span were to be spaced 3 ft. 9 in. centre to centre. I said that conservative practice would limit the width of the table of such a T-beam with a 3-in. slab to 3 ft. 9 in., which means that 3 ft. 9 in. is all the width that would be assumed to be developable—the centres of beams could be any distance apart you will, within reason.

If Mr. Rings wished to stipulate for various other assumptions in using his calculators he should have set them forth. I showed in my example that Mr. Rings' calculators were correct at one fixed depth, and I do not see how he can draw his "logical conclusion" from my sentences, to which he refers, that "the reckoners give false results." Indeed, I said in my review that the T-beam calculators were "roughly approximate" if one made certain assumptions that were not always warrantable in design.

Mr. Rings is apparently prepared to admit that for a beam of fixed loading and span his calculators fix the depth, and require, in order to develop his fixed stresses, a fixed depth of slab. Yet he at the same time shows the feasibility of the thickness of the slab varying with the degree of continuity and the employment of double reinforcement, although the superload remains fixed. That surely means that the calculators are roughly approximate.

I have also substantiated my statement that the calculators could be used in such a way as to afford serious errors in overstressing the concrete, and I do not think it advisable that the non-specialist should make such mistakes.

As regards economy, the word is rather an elastic one, but I think it would be readily admitted that various considerations affect the matter, and architects and others cannot, and would not, always space beams by any general rule. Therefore, in stating that "it is most economical to make the distance of beams equal to one-third of the span," Mr. Rings is evidently limiting the application of the word, for he goes on to state, "no designer would carry out such a floor as your reviewer states, he would, of course, adopt subsidiary beams."

I am anxious to be perfectly fair to Mr. Rings, and I appreciate his efforts to assist in simplifying reinforced-concrete calculations, and I would not for a moment throw any aspersions on his ability as a designer of reinforced concrete. I have no doubt that he can use his calculators with advantage, knowing their limitations. I merely expressed doubts as to their utility as published to others.

REVIEWER, C. AND C. E.

[*Mr. Rings having apparently some grievance as to the review that appeared in these columns, we have afforded him space for putting forward his arguments in the form of two letters. This correspondence must, however, now cease.*—ED.]

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Visit of Members of the Society of Engineers to the Works of the Associated Portland Cement Manufacturers at Swanscombe.—On July 7th, 1911, by permission of the Associated Portland Cement Manufacturers (1900), Ltd., a number of members of the Society of Engineers and their friends visited the Swanscombe Cement Works of that company.

The district in which these works are situated is peculiarly adapted to be the centre of the cement industry on account of the presence of unlimited supplies of chalk and clay, an ample quantity of fuel, and ready access to all parts of the world through the Port of London.

The visitors were shown the chalk and clay quarries adjoining the works, The amalgamation of chalk and clay in definite proportion is effected by batteries of washmills, the resulting slurry passing through a screening mill in a finely divided state. The slurry then passes into the large mixing and storage tanks, and is finally pumped into rotary kilns, in which the contained water is evaporated, and the dry material thus obtained is heated up to a temperature of about 2,800° F.

The hot clinker then passes through rotary coolers, which extract the heat, and from thence is delivered to the grinding mills, in which the clinker is reduced to a very fine powder. During the final stage of the grinding process steam is injected into the mill, subjecting each particle of cement to a repeated process of superficial hydration, thus regulating the setting time, and turning out the cement in a condition for immediate use, thereby obviating the trouble of turning over the cement before use on the site of works.

The visitors were shown the cooperages, where casks for packing cement for export are made by machinery, many of the machines being of a special character, and patented by the company.

Tea was provided by the company for their guests at the conclusion of the visit, after which a vote of thanks to the company for their courtesy was proposed and heartily accorded.

German Portland Cements.—The annual report on the samples of Portland and other cements examined in the testing laboratory of Gross-Lichterfeld has just been issued by Professor Burchartz. During 1909, the year covered by the report, 150 Portland cements were tested, of which 135 were slow-setting, and 15 quick-setting. Whilst all the samples withstood the cold water test for soundness, 19 failed in the boiling test. Five cements left more than 5 per cent. residue on the fine sieve. Two cements failed to reach the prescribed tensile strength after 7 days, whilst 12 failed to reach the required compressive strength after 28 days under water. The specific gravity lay, in the great majority of cases, between 3·05 and 3·15, or after ignition, between 3·20 and 3·25. A special series of tests showed that those cements which failed in the boiling test were inferior in strength to those which withstood the test, but most of them nevertheless satisfied the requirements of the Prussian Standard Specification as to strength. The figures show a very considerable increase in the average strength of German Portland cements from 1907 to 1909. The number of cements, other than Portland, examined is too small to permit of a useful comparison being made.

Effect of Delay after Gauging Mortar on its Strength.—Professor Burchartz also publishes the results of tests to determine the influence of the time elapsing between the gauging of a mortar and its filling into the moulds on its strength. A slow-setting cement being taken (initial set 3¼ hours), it was found that storage for 3 or more hours injured the mortar, whilst an interval of 5 hours or more largely destroyed its strength. The effect is greater the more water is used in gauging.

Discovery of an Early Example of Reinforced Concrete.—In a recent number of the *Figaro* of Paris an account was given of a strange discovery at the Louvre in the walls of the old palace. While carrying out the works for the lift it was necessary to pierce some of these walls, which were thought to consist entirely of ashlar and quarry stone. What was therefore the stupefaction of the builders entrusted with the execution of the work on discovering that the stone casing of these walls concealed a core composed in part in a kind of reinforced concrete! Reinforced concrete three or four centuries old, when this building material was believed to be quite a modern product!

Testing a Cellular Reinforced Concrete Floor at the Brussels Exhibition.—With reference to an account which appeared in our June number regarding a load test on a "cellular reinforced concrete floor" at the Brussels Exhibition, we are won enabled, through the Armoured Tubular Flooring Co., Ltd., to submit a block showing the sample before test, from which it will be seen that the method of construction adopted was that of the armoured tubular floor, the sample having been constructed by the licensee of that system for Holland.

Samples of Armoured Tubular Flooring before the Test.

The relationship of designed load 60 lb. to breaking load 650 lb. per sq. ft. proved in this test what has been frequently demonstrated by previous successful loading tests, the large reserve of strength possessed by this system, which combines high efficiency in design with great economy in material and construction.

Below we give the official report on these tests:

Official Report upon Resistance Tests of Armoured Tubular Floor Sample shown in the Pavilion of Works at the Brussels Exposition of 1910. Certified.

These tests were made upon December 5th, 1910, in the presence of Major Dubuisson, delegated by the Minister of War, assisted by Lieutenant Wiener.

The sample submitted for test was a floor slab of 23 ft. 8 in. in clear span, and of 4 ft. 3 in. in width. It was formed of five webs of 9½ in. in height, containing in their lower wider section a reinforcement of 4 c/m^2 (2 in. by $\frac{1}{4}$ in.), in section ; between the webs were placed concrete tubes. The calculated applied working load being 300 kg. per square metre, or 60 lb. per sq. ft. There were placed under the floor five instruments for amplifying deflections, two at the ends, one midway between these, and two half-way between centre and ends. It is certified that the five deflection meters were placed at zero.

First Test.—The floor, having been charged to a load of 450 kg. (90 lb.) per square metre, or 1$\frac{1}{2}$ times the calculated super load, it is certified that the central deflection was 2·2 mm. (0·08 in.), or $\frac{1}{3272}$ part of the span.

Second Test.—The loads having been completely removed, it is certified that the permanent set in the centre of span was ·2 mm., or $\frac{1}{36000}$ part of the span.

Third Test.—The sample, having been loaded afresh, the deflections observed are stated under, corresponding to loadings of 1$\frac{1}{2}$, 2, 3, 4, 5, 6, and 7 times the calculated super load. The first column indicates the deflections found during first test ; the second those when unloaded, (indicating permanent deflections from first test), whilst the others refer to the third test and those following.

DEFLECTIONS IN CENTRE UNDER LOADS STATED.

Kg. per sq. metre	450	0	450	600	900	1,200	1,500	1,800	2,100
Lb. per sq. ft. ...	90	0	90	120	180	240	300	360	420
Mm.	2·2	0·2	2·2	3·0	5·0	7·75	10·95	14·5	18·8
In.	$\frac{6}{64}$	$\frac{1}{64}$	$\frac{6}{64}$	$\frac{8}{64}$	$\frac{13}{64}$	$\frac{20}{64}$	$\frac{29}{62}$	$\frac{29}{64}$	$\frac{50}{64}$

At 1,800 kg. per square metre the first fissures were found in upper zone over the ends ; at 2,100 kg. per square metre, a slight fissure occurred in the lower zone in centre.

The deflection meters were removed, and loading continued. At eight times the surcharge, or 2,400 kg. per square metre (480 lb. per sq. ft.), no fractures have been produced, only the fissures are slightly enlarged. Finally, by augmenting the load in the centre of span to 3,250 kg. per square metre (650 lb. per sq. ft.) rupture was produced, the breaking load being 10·83 times the designed working load. The deflection meter readings were taken by Lieutenant Wiener.

Concrete for Railways.—The use of concrete for commercial buildings, for dwellings, etc., has shown a remarkable growth. The use of this material by the railways in different classes of structures has also rapidly increased.

There are many properties of concrete which are of special value to a railway. Its fire-resisting qualities not only save a loss of the structure in many cases, but also, in the case of arches, culverts, and trestles, give a greater safety to the road-bed and eliminate the danger of serious wrecks, which may result in loss of life as well as loss of property, to say nothing of delays occasioned when one of these structures is burned out. Railway structures may at any time be subjected to fire from passing locomotives. Thus, on account of the increased danger of fire, concrete construction should show even greater advantage for railway than for other structures. Another advantage of concrete waterways is their low maintenance cost and the need for less inspection, as compared with structures composed of steel or wood. This is on account of the non-corrosive character of concrete as well as its resistance to fire.—*Railway Engineering.*

Concrete Shaft Work in Mines.—One of the greatest pieces of concreting undertaken in the Lake Superior region is that in progress at the Cleveland Cliffs Iron Co.'s Maas mine at Negaunee. The shaft at this property was sunk a number of years ago. The overburden was of quicksand, 167 ft. in depth, and to penetrate to the ledge required many months' hard work and the expenditure of a large sum of money. Millions of gallons of water and sand were pumped out of the opening, and long before the rock was reached there had been created a huge excavation, projecting from the centre of which was the shaft timbering. There was much twisting and buckling, as was to be expected, and when the shaft had attained the ledge it was badly out of alignment.

Hoisting operations have not been satisfactory, due to the shaft's irregularities, and, with the mine now well opened and prepared to furnish a large tonnage of ore, it was decided to put the property in the best possible condition by making the outlet safe and stable. This is being done by giving the shaft a heavy lining of concrete from the surface to a point some 30 ft. below the ledge. The work is being performed by the Foundation Co., of New York.

The concreting will be dropped from the surface, the weight of the material forcing the structure downward. It will be of very massive construction, and will weigh enormously per running foot of completed circle. The outer portion of the shaft will be round, while the dimensions of the interior will be 14 ft. 10 in. by 10 ft. 10 in. The walls will not be of the same thickness. They will be 7 ft. 11 in. at the bottom, and for a considerable distance above it, and from the latter point will gradually narrow, until at the surface the width will be 2 ft. 6 in. The greatest thickness will be where the pressure exerted against the concrete from the surrounding formations will be the heaviest, which will be at the bottom of the shaft, the width growing proportionately less as the surface is approached. The walls will be reinforced with steel. The concrete will be carried well into the ledge. The latter rises up in one side of the shaft at an angle of 70°. When finished the concreted portion of the shaft will be about 200 ft. from surface to bottom. Concreting this shaft is a huge and at the same time a most delicate piece of work. The sand will run like water and in almost inexhaustible volume if once it is given a chance, and the utmost caution must be exercised. Failure to take proper care would easily wreck the entire shaft. When completed the mine will be equipped with a shaft that will stand as long as the mine has ore to take out, and this will be a great many years.

The Cleveland Cliffs Co. is also concreting its Negaunee mine shaft. This work, while by no means easy of accomplishment, is less difficult, not so hazardous, and much less expensive per lineal foot than that at the adjoining property. The Negaunee's overburden is quite as unstable as that of the Maas. There were several bad runs of ground prior to the Cleveland Cliffs taking hold, lives were sacrificed, and the wrecking of the property was threatened. The concreting of the shaft, which has been in progress a number of months, is now nearing completion. It will not be many weeks before it will be possible to begin installing the shaft equipment. The concrete has reached the ninth level, the principal working point in the property, and will be continued downward until the tenth level is attained. Concrete pockets are to be put in at the ninth level. These will be the first underground pockets of that nature on the Marquette range. They will be reinforced with steel, and will be lined with the same material. The shaft will be of concrete from top to bottom. In practically all of the concrete shafts in the Lake Superior district the concrete reaches from the surface only to the ledge, but in the Negaunee shaft the ledge has been cut away in order to make room for the concrete walls.—*Cement.*

Surface Finish for Concrete Blocks.—Surface finish for concrete blocks, consisting of a facing of 1 : 2 mixture of cement and limestone screenings smoothed off on a revolving metal disc covered with wet lake sand, was used, says *Engineering Record*, in the construction of the new office building for a cement company at Buffington, Ind. Another method of facing concrete blocks was used at the State hospital, Yankton, S.D., and the State hospital at Elgin, Ill. The blocks for these buildings are faced with thin pieces or chips of granite of irregular shapes and sizes, split by hand from larger pieces. A layer of sand about ½ in. thick is first spread over the bottom of the form, and upon this sand the stone facing is laid. A rich mortar, 1 part universal Portland cement and 1 part sand, mixed very wet, is then poured over the stones, and immediately after the forms are filled with an ordinary 1 : 2 : 5 concrete. The blocks are left in the forms until the following day, when they are removed and cured, and, without further treatment, are ready to be placed in the wall.

TRADE NOTICES.

Mason's 1911 Lead-Carbo Tread.—We have received particulars of a new stair-tread put upon the market, and termed "Mason's 1911 Lead-Carbo Tread." This new form of step is a grooveless one, which is a great improvement over the older forms of patent stair-treads, as there are no grooves to collect dirt and germs. The qualities of non-slipping and of durability which are possessed by Mason's steel and lead treads are maintained in their latest production. The dovetailed steel is used containing lead, alternate rows being separated by the "U" groove, which is perforated at the base in series of slotted holes countersunk on the underside, and made a receptacle for carborundum chemically combined into a cement. This possesses great abrasive properties when applied as a step surface and made flush with the existing lead portion of the tread. This combination of steel, lead, and carborundum gives at one and the same time a hard and soft resistance to the foot which is very agreeable.

It is claimed that Mason's combination of rolled steel and lead in this patented form will last twenty years under the severest conditions, for the durability of the steel is doubled, owing to the fact that the carborundum receives the friction that otherwise would be taken up by the thin edges of the " U " grooving alone.

A Novel Pile-Driver.—It is surprising with what cumbersome devices the majority of contracting work is done in building and constructional engineering. Out-of-date plant is made to serve, and time and labour are wasted in a most extravagant fashion. Often one job alone would handsomely pay for installing new and efficient plant, and in most cases the money expended would soon be repaid. Pile-driving is a case in point, though considerable improvement has been effected in this respect in recent years.

The Southgate Pile-Driver Co. have now, however, put upon the market a pile-driver of a very improved form. Most steam pile-drivers have an independent dolly, and in one type the flexible tube is attached to the monkey and moves up and down with it with every stroke of the monkey, thus bringing an undue pressure on the flexible tube. In others the piston rod is extended through the bottom of the monkey and thus by condensation tends to wet the block on the top of the dolly. The Southgate pile-driver employs a different device. It will be seen from the illustrations that the dolly which rests on the head of the pile to be driven is connected by two vertical rods to a steel crosshead which carries the piston-rod and piston on which the steam cylinder forming the monkey works.

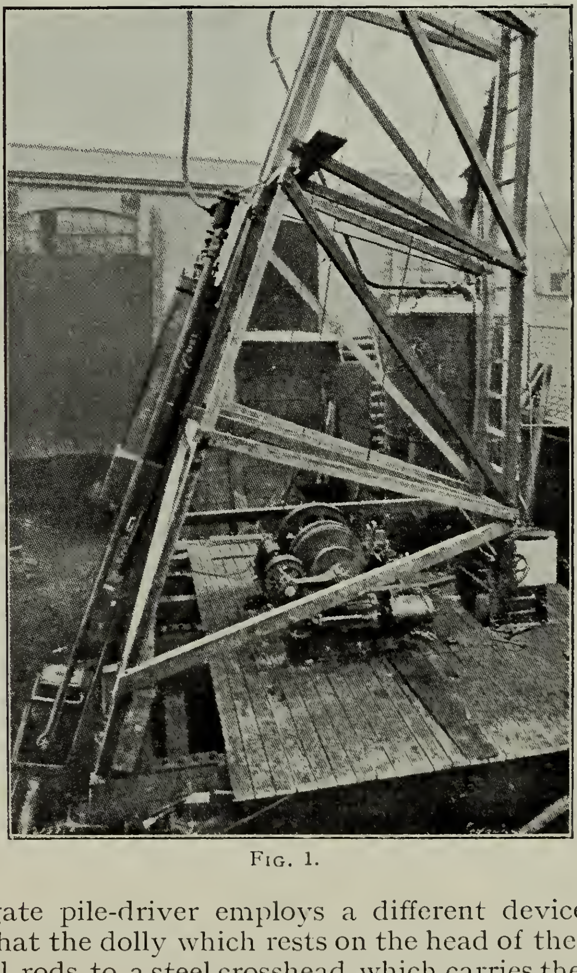


Fig. 1.

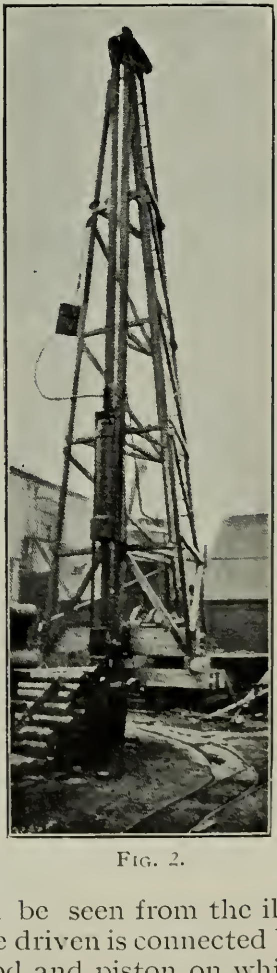


Fig. 2.

The flexible steam-pipe supplying the cylinder is led to a valve mounted on this crosshead, this valve being connected up to a steam passage made down the centre of the piston-rod. The James Garvie patent steam-monkey, with which these pile drivers are fitted, has a solid bottom, formed into a square hammer-head, suitable for giving

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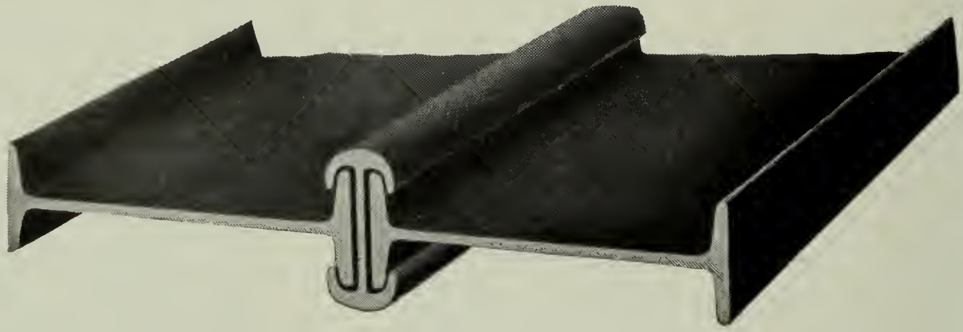

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a solid blow. The solid-end formation of the monkey also prevents the leakage of condensed steam on to the dolly.

The monkey is of single-acting type, steam being used to lift it after each stroke. The connection from the steam-pipe passes through the valve at the top of the piston-rod and through the piston-rod to the cylinder. The valve is automatic in so far as that by means of an internal spring it opens to exhaust at the right moment, so that the monkey falls freely. The back pressure is very small. It is claimed that about double the number of strokes per minute can be obtained with this arrangement as compared with that used on older types of drop-monkeys, while a heavy monkey with a short and rapid stroke is generally held to be most effective in driving concrete piles, and least likely to damage them at the head.

The flexible steam connection does not move up or down with the monkey, so that it is not subjected to continual strains. It has only a gradual downward motion along with the dolly and crosshead. Other advantages of the arrangement which should be mentioned are that the whole weight of the monkey is always on the pile during driving, and that there is no strain on the woodwork due to driving. This latter point is of special importance when working from a barge. In the upper part of the dolly an elm block is fitted which receives the blow from the monkey. This monkey is capable of giving about 50 blows a minute. Three of these pile-drivers have been used by the Buenos Ayres Dock Co. and also by the Indian Government.

Labour's Pavements, Ltd.—In our June number we made reference to a flight of stairs in Paris erected with concrete in which a good proportion of carborundum had been mixed, thus making the steps almost imperishable. Messrs. Labour's Pavements, Ltd., now inform us that they are also carrying on similar work in this country for public corporations, railways, etc., and not only in the form of concrete stairs, but for platform edgings, ornamental, coloured, or white-tiled entrances, stable briquettes, etc.

Shingle and Sand at Southampton Deep-Water Dock.—This dock was described in our July issue, and with reference thereto Mr. Frank Bevis, contractor of Portsmouth, inform us that the whole of the shingle and sand used in the above work was supplied by him, the approximate quantities being: Shingle, 450,000 cu. yd.; sea sand, 45,000 cu. yd.

ENQUIRY.

One of our subscribers writes to us as follows:

"Will you kindly inform me from what source I can gather information as to the action resulting from immersing concrete castings in a solution of silicate of soda (s.g. 1·1)?"

Can any of our readers give us results of experience in this connection?

CONTRACTS.

The Indented Bar and Concrete Engineering Co., Ltd., have sent us the following list of works in which the reinforcement is indented bars, which are now being carried out or are about to be started: Two mills in Bolton and a mill in Truro; warehouse, Deptford; Gramaphone factory, Hayes; retaining wall, Ventnor; warehouse, Raynes Park; extensions to Guy's Hospital; chimney, Charing Cross and West-End Electric; road bridges, Somerset; retaining wall, West Ham F.C.; mill, Greengates; extensions to works, Darwen; schools, Durham and Fenton; club, Peterborough; factory, Birmingham; mills at Bradford and Keighley; bridge in Ilkeston; brewery in Greenwich; bridge in Baker Street, London; tank, Nelson.

Messrs. G. Jackaman & Son, of Slough, have obtained the contract for the erection of Cold Storage Buildings, Queen Alexandra Dock, Cardiff, for the Cardiff Railway Company.

Messrs. Edmond Coignet, Ltd., inform us that their system of reinforced concrete has recently been adopted for the following works:—

Second carpet warehouse, Bailiffe Bridge. Architects, Messrs. Walsh & Nicholas, of Halifax; contractors, Messrs. Henry Atkinson & Sons, Ltd., of Leeds.

Third extension to Victoria works. Architects and contractors, ditto, ditto.

New engine-house, Bailiffe Bridge. Architects and contractors, ditto, ditto.

Gun shed at Cardift. Architect, W. H. Dashwood Caple, F.R.I.B.A., of Cardiff; contractors, Messrs. Watt Bros., of Cardiff.

Floors for large three-storey building at Lancashire. Extensive foundation for machinery in Lancashire. Floors for new Headingley Training College, Leeds. Architect, G. W. Atkinson, Esq., of Leeds; contractors, Messrs. Henry Atkinson & Sons, Ltd., of Leeds.

Roof to National Hospital, London. Architect, R. Langton Cole, Esq., F.R.I.B.A., of London; contractors, Messrs. Patman & Fotheringham, of London.

Coal bunkers at Larne, Ireland, for the British Aluminium Co. Contractors, Messrs. The Irish Armoured Tubular Flooring Co., Ltd., of Belfast.

Three tanks for the London City & Midland Bank. Contractors, Messrs. Colls & Sons, of London.

Two bow-string bridges for the Powell Duffryn Steam Colliery, South Wales. Contractors, Messrs. Watt Bros., of Cardiff.

Raft foundations for St. Luke's Church, Grimsby. Architects, Messrs. Nicolson & Corlette, of London; contractors, Messrs. John Thompson & Co., of Peterborough.

Raft foundations, piles and retaining wall at Brentford. Contractors, Messrs. D. G. Somerville & Co., of London.

Foundation for Colston Girls' School, Bristol. Architects, Messrs. W. S. Paul & James, Bristol; contractors, Messrs. John Perkins & Son, Ltd., of Bristol.

New pier, 850 ft. long, at Padstow, for the Harbour Commissioners. Engineer, Sir G. Croydon Marks, M.P., of London; contractor, Arthur Carkeek, Esq., of Redruth.

Flat roof for Messrs. T. Walker & Son, Birmingham. Contractors, Messrs. R. Fenwick, Ltd., of Birmingham.

Extensive premises for Messrs. J. & E. Wright, Ltd., at Birmingham. Contractors, Messrs. R. Fenwick, Ltd., of Birmingham.

Besides the above-mentioned new contracts, Messrs. Edmond Coignet are at present finishing the preparation of the plans for the

Public buildings, East Block, at Kingston, Jamaica. Architects, Messrs. Nicolson & Corlette, of London; contractors, Messrs. Mais & Sant, of Kingston, Jamaica.

They are also terminating the floors of the

Royal Infirmary at Bristol (architects, Messrs. Adams & Holden, of London; contractors, Messrs. William Cowlin & Son, of Bristol; and also the new road bridge at King's Cross Station for the Metropolitan Railway (contractors, Messrs. William King & Son, of London).

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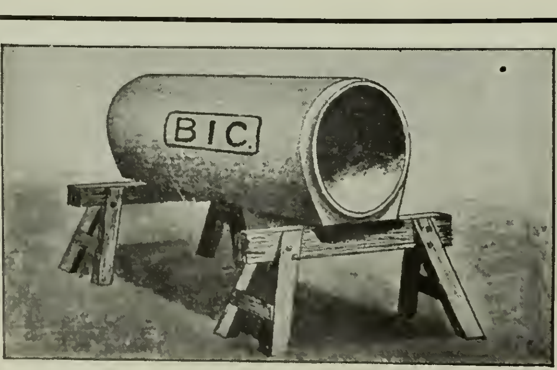

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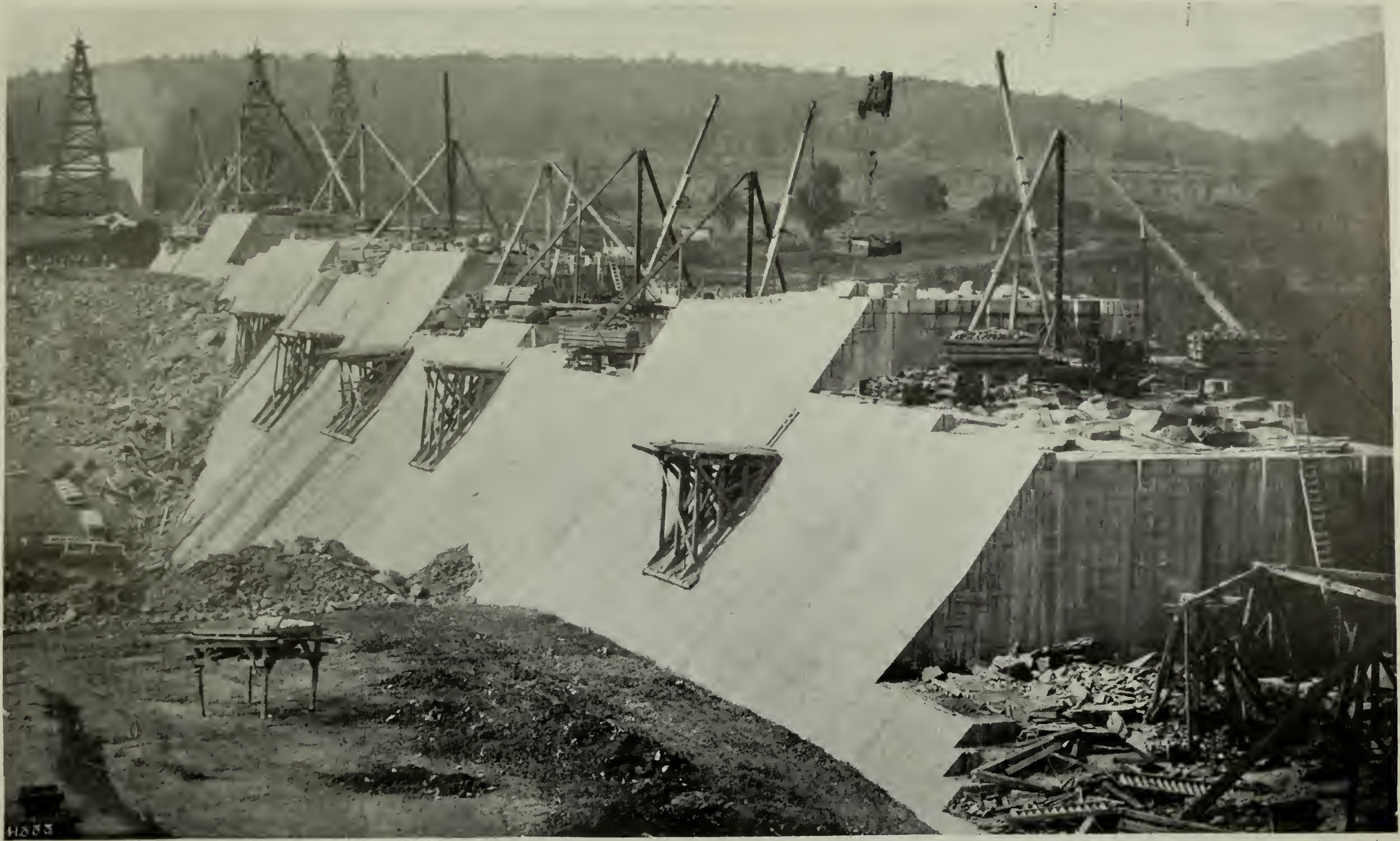


(*Frontispiece*)

Downstream face of the Olive Bridge Dam, faced with concrete blocks.

The Catskill Mountain Waterworks for New York City.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume VI. No. 9. London, September, 1911.

EDITORIAL NOTES.

THE SECOND REPORT OF THE JOINT COMMITTEE ON REINFORCED CONCRETE.

THE REPORT TECHNICALLY CONSIDERED.

THE Second Report of the Joint Committee on Reinforced Concrete appointed by the Royal Institute of British Architects is in manner and matter substantially the same as the first. There are various additions, but few differences.

The principal alterations are in the section on methods of calculation, and consist in the recasting in form and the redressing in the standard notation proposed by the Concrete Institute. The methods of calculation are, however, governed by the same theoretical standpoint.

In offering our comments upon the technical matter of the report, we must firstly point to our general comments in the preceding issue of this Journal, and secondly record our high appreciation of the advantages which were derived from the first report issued in 1907. It regularised practice in this country and gave some authoritative recommendations to which designers could appeal, and it gave some sort of sanction to a novel method of construction on which professional men generally might rely in recommending their clients to adopt it. The first report was very useful, and in revising their report up to date we would again record that the Committee has performed further good service.

FIRE RESISTANCE.

Our first criticism is in respect to Clause 3 referring to fire resistance. The Committee have taken a moderate view and suggested the very minimum that could be permitted. Of course, in a report which seeks to impose restrictions upon the building community the adoption of a minimum is the right course ; but when it is possible to distinguish clearly more than one grade of construction, it would be better, we think, to classify the grades and to lay down the minimum for each rather than to specify the minimum for the lowest, which the Committee speak of as " in all *ordinary* cases." It is true that it is also noted that " more perfect protection to the structure is required under very high temperature, and in the most severe conditions it is desirable to cover the concrete structure with fire-resisting plastering which may be easily renewed." We are safe in saying that " in the most severe conditions " plastering would not be sufficient protection. The notion that high temperature is the sole determining factor, as seems to be suggested, needs correction, for even in small conflagrations the temperature generally rises locally to as high a degree as in the larger, but the great difference is that it does not continue thereat for long. It is the long continuance at a high temperature which does the mischief, and where inflammable materials are stored in bulk and the concrete is thoroughly dried out by heating the buildings, the 1 in. protection on beams as advised is quite inadequate, even in "ordinary cases." Two inches of concrete covering with aggregate that will pass a $\frac{3}{4}$-in. sieve is the practical minimum of protection that should be afforded in everyday practice. The tests of the British Fire-Prevention Committee have proved this time after time. It also seems a pity that the Committee did not advise as to the protection of "ordinary" columns instead of limiting themselves to slabs and beams, because the columns are of primary importance. For columns, $2\frac{1}{2}$ in. would be a practical minimum, and 3 in. a preferable minimum covering. We would also remark that it is not only temperature that must be considered, but the application of water for the purpose of extinguishing the fire or stopping the conflagration from spreading. In this respect the advantages of rounded corners have been proved by the Fire-Prevention Committee's tests.

WASHING SAND.

Next regarding "Clause 5—Sand," we find it stated that "washing sand does not always improve it, as the finer particles which may be of value to the compactness and solidity of the mortar are carried away in the process." Such statements show the frequent error of drawing conclusions from a few experiments without having definitely established the true cause of the variation in the general results. The cause might have been found in this case, however, from several sources of information on concrete. It is due to a difference in the proportion of voids, the material removed by washing filling some of the voids, and so enabling the cement to do better service than in the filling of voids. In washing sand the finer particles need not necessarily be removed, and it is an invariable rule that natural sand is improved by washing it, provided the voids are filled either by grading the sand or by employing extra labour, for the loam, salt, vegetable, or other matter are alike deleterious in themselves to cement, though they may do more good than harm by filling the voids in a badly graded mixture.

STEEL.

We now come to "Clause 8—Metal," the title of which would suggest that it were not limited, as it is, to steel. Why not wrought iron if available, and why steel limited to a minimum ultimate strength of 60,000 lb./in.^{2}? If the metal possesses a well-defined yield point and is ductile, why suggest that it be prohibited because it falls below 27 tons? We conclude that the Committee wished to raise the standard of manufacture as is attempted by standard specifications, so that users may not be supplied with a variable material, which one week may be worth 30 tons and the next, say, 24 tons. But we are inclined to think the purchaser might be better protected by having his eyes opened to the possibility of variation, and by being advised to compare quality as well as price, and impressed with the desirability of close checking by means of tests and the limitation of variation. Thus if, for instance, we could purchase a steel whose resistance was, say, 24 to 26 tons/in.^{2} with proper ductility and yield point of, say, 14 tons at four-fifths the price of 28 to 32 ton steel, we see no reason why it should not be used, and in certain circumstances it would be preferable for reinforced concrete work.

We find nothing else in the section on materials to adversely criticise. It might have been advisable to have added further recommendations, but we do not note anything of great moment excluded, and, on the whole, we think it very sensible and sober.

SCIENTIFIC CALCULATIONS.

The section on Methods of Calculation must be somewhat contentious at this stage in the evolution of a comparatively new subject. We think the most obvious comment is perhaps its chief objection, whereas to many it may seem at first sight a recommendation—namely, that it agrees generally with the rules that have been proposed by other committees, commissions and building authorities. We feel that, when there is such unanimity of opinion in such a new method of construction, there is the greater probability of all being uniformly mistaken, for it shows that the new problems are being regarded from old and accepted standpoints. The more one delves into structural design, the more one finds things in doubt. It is like other branches of science, in that the more any aspect is investigated, the larger it grows. We suppose here the reader will object, " Yes, but the main principles or laws become more general and more confirmed." That is so, but in architecture and engineering there is a difference. It is a science that is synthetical as well as analytical, and more the former than the latter—that is to say, it is the tendency of the engineer primarily to use analysis to give him an equipment only sufficient for his immediate constructive purpose. Consequently, he is not greatly interested in going deeper and deeper into the analysis, and is inclined to assume that, because his elementary rules have sufficed for much practical work, they are therefore established as correct. So we may naturally expect the majority of members of the constructive professions to agree in accepting as laws what experience in other branches of science would suggest were but the first drafting of generalisations, for they have undergone such little modification—as theories, they have not been put to the scientific tests of comparison with experimental data, but only to practical tests.

We regret, therefore, to find such little originality in the Committee's work, and we hope that the unanimity in these commonplaces may not be mistaken as well establishing the methods, so that, when we do get a better theory, it may be hampered from employment by precedents and the like conservative impediments ; nor that the more original and more scientific engineer may be interfered with and deterred from employing his superior methods by ignorant prejudice. The only thing that can be said in favour of such rules and formulæ is that they appear to be on the safe side, but appearances are often deceptive, and, when we see things only dimly, we feel doubts as to our way and fear we may plunge over a precipice at any moment. More light is wanted, and unfortunately the Joint Committee's Second Report does not help us here, though it is distinctly helpful in many other ways.

ACCIDENTAL LOADS.

As regards loads to be taken, the reduction of accidental loads on storeys below the top one is quite legitimate practice with the majority of structures, but as to whether that reduction should be 5 or 10 per cent. is a moot point.

In American practice one frequently finds it specified that allowance should be made for concentrated, as well as distributed accidental loads. That suggests the advisability of the inclusion of a similar provision.

SPANS OF BEAMS.

The suggestion that the span of a beam should be taken as the distance from centre to centre of bearings refers to a matter where some originality of treatment would be welcome. There is distinctly room here for more accuracy, and the point is of considerable importance in beams of long span.

CONTINUOUS BEAMS.

Attention is directed to the effect of supports of continuous beams not being at the same level, and we would also suggest the advisability of calling attention to the effect of variation in moment of inertia. The question of continuity in beams is skipped over lightly, but it is important, and current methods of making calculations are susceptible of much improvement, and we wish the report had helped.

MODULI OF ELASTICITY.

It is strange that a uniform value of 15 for the modular ratio of elasticity of steel and concrete should be proposed, while variation in the qualities of concrete is provided for, and it is known that stronger concretes have a correspondingly higher modulus. The French Commission's Report allowed for variation in modulus, and we think that is the only strictly scientific way of treating it.

Another peculiarity is that this modular ratio is referred to under beams, where possibly it is not of much importance, while it should be stated as part of the next clause, where it is stated, in other words, as 15 for pillars.

WORKING STRESSES.

"Clause 5—Working Stresses," is out of place, it should come after Clause 1. because it does not refer solely to beams. We note here that the safe compressive strength of 1,800 lb. concrete is taken at 600 lb. both for columns and extreme fibre stress in beams, whereas, it was the older view, and we think the more reasonable one, that more could be taken for beams than columns. It is still stated, too, that the concrete in shear is to be limited to 60 lb./in.^{2}, but that is only logical for beams not reinforced against diagonal tension, and can only be intended as a measure of diagonal tension. Steel in shear is valued at 12,000 lb./in.^{2}, but it is very seldom that it is so employed in reinforced concrete; we shall refer to this again later.

The safe strength of "adhesion or grip of concrete to metal" is retained at 100 lb./in.^{2}, but it is emphasised in a footnote that "precautions should in every case be taken by splitting or bending the rod ends, or otherwise to provide additional security against the sliding of the rods in the concrete." There is much ambiguity of current thought displayed in respect to the subjects of shear and adhesion, and there are strong opposing partisans of continuous mechanical bond and plain rods. Although adhesion-friction bond between concrete and steel has been established by many tests, and may perhaps be set safely at 100 lb./in.^{2} in average cases, the Joint Committee evidently recognises that doubtful reliance is to be placed on it, because it makes the recommendation as to splitting or bending the ends of rods, and in another place advises the anchoring of stirrups at their top ends, precautions which conservative practice has always adopted. When such mechanical bond is secured the adhesion-friction bond may be neglected, and therefore the Committee's further recommendation, that "it is desirable that the reinforcing rods should be so designed that the adhesion is sufficient to resist the shear between the metal and concrete," becomes unnecessary. It also betrays the peculiar view of shear stresses which we refer to later on.

BEAM THEORY.

The method of making calculations for beams with single reinforcement has been changed from the first report, and now specially refers to T-beams, but Captain Fleming in an appendix treats the formulæ more in detail, and applies them to rectangular beams, so that there is no need for the report to deal with either. Indeed, there would have been much advantage in leaving them for an appendix, for the formulæ are by no means beyond dispute, and indeed have not been employed for the majority of work successfully executed, whereas they would imply that the constructors must often have been very wrong, and their work in danger of collapse, of which records do not show any signs, nor any proportion of unexplained failures to warrant such an assumption.

We may here note that it is recommended that the width of the rib of a T-beam should not be less than one-sixth of the width of the flange No reason is vouchsafed, and we venture to suggest that there is none adequate. Mr. J. E. Conzelmann, in a letter to our columns upon the first report of the Committee, once gave a clue to a means of arriving at a very simple formulæ that would be more correct than the rule given, but even then the same method of calculation would be employed as the Committee's, and there are reasons for doubting its accuracy, as we have said.

SHEAR REINFORCEMENTS.

We are glad to now come to one of the chief additions to the second report—namely, rules for the determination of shear reinforcement. This part seems to be produced in view of the method of treatment which is favoured by Professor Mörsch, and by American professors who have followed him, and which is set forth in an appendix to the report by Mr. William Dunn, although Mr. E. Fiander Etchells has added an appendix which would lead to the conclusion that the tensile resistance of the shear members could be more correctly adopted than the pure shear value of steel. The other method set forth by Mr. Dunn seems illogical, because it assumes that vertical shear is transmitted horizontally by the concrete, which it could not do if it were cracked as the report assumes it to be by setting out that the tensile resistance of the concrete must be ignored.

The treatment of the subject generally in the report is coloured by this point of view, and it is in a way responsible for the idea of so much variation of stress in the flange of a T-beam to which we were referring above when we remarked about other constructors, who assume the flange to be evenly stressed.

In this same section we see it stated that the shearing reinforcement should be provided at "Distances apart not exceeding the *depth* of the beam." From Mr. Etchells' point of view, it should be the arm and not the depth, and we believe this to be correct. We are glad to see it advocated that stirrups should be anchored at both their ends, though if certain precautions are adopted it is not essential.

DETAILS OF DESIGN.

Except in what we have noted, the design of reinforcement in detail is not dealt with, yet we believe that just as in steelwork practice, the details are often the weakest parts of designs. It is most frequent for the sections employed in steelwork to be ample, while the connections are scamped because they entail labour. So also in reinforced concrete, what we might almost call connections and similar details, though we believe not exactly scamped, are overlooked, whereas they are of the utmost importance to stability.

PILLARS.

Another of the chief additions to the report is the section on "Pillars and Pieces under Direct Thrust." Here the Committee really has produced something original, and we believe it to be the best ruling on reinforced concrete columns yet put forward, for it has regard to the increased strength derived from lateral binding. Firstly, we have to remark that the reason why the sectional area of longitudinal reinforcements is put at a minimum of 0·8 per cent. of the cross-sectional area of a column is not stated. There are indeed a number of similar recommendations which ought to be explained, if they are to meet with ready acceptance.

Now, the formulæ for hooped concrete are of the nature of empirical formulæ, being based on practical experiments, and not so much on theory derived therefrom. The formulæ permit the concrete to be stressed more highly and in proportion to the kind of lateral binding and to its spacing. We see good reason in the adoption of a form factor, though its value may be questioned, but the spacing factor is not so obvious, for it is made to vary only with the spacing, whereas it seems it ought to vary with the ratio of lateral reinforcement, for it presumably depends upon the distance of concrete that may be safely left unsupported, which varies with the stress upon it, and the stress is expected to vary with the ratio of lateral reinforcement. Also, we see the formula uses a symbol, r, to represent the ratio between the volumes of lateral and vertical reinforcements, but supposing two columns of equal size had the same total volumes of helical laterals and vertical reinforcements with the same close spacing, but one helix was heavier than the other, is it not reasonable to suppose the concrete in the heavier helix could be more highly stressed? We have only examined a few results at present, but it seems to us that the formula would be more adequate if the lateral reinforcement were, within limits perhaps, alone considered without regard to the vertical reinforcements; but then, of course, a rule would be needed for the determination of the section of the laterals, but as that must depend upon the stress which is put in them by the tendency to lateral expansion, we find no insuperable difficulty in arriving at a formula which would be more theoretical, and possibly accord more closely with the results of tests.

We do not follow the idea in limiting the stress on the concrete core to a proportion of the ultimate resistance as a plain cube. If a safety factor be needed on plain concrete, it is in great part because of probable variations in quality, and supposing the quality to have the maximum of inferiority, it seems to us that if the stress should reach 0·66 of the standard limit of resistance, the ultimate resistance would be completely exceeded, so what then would become of the "Limit of continued endurance for plain concrete" referred to in the report? We can see no reason why, if the spacing be close, the ultimate resistance as a plain cube should not be exceeded.

ELECTROLYSIS.

Regarding omissions in the report, we find no word of warning concerning electrolysis and its dangers, of which some interesting cases are on record.

APPENDICES.

As regards the appendices, Mr. Etchells utters a timely warning against some empirical rules for rectangular slabs, and the report warns us that there is no satisfactory theory, nor trustworthy experiments, yet in this respect. Professor Unwin's two early contributions are retained, as also Mr. Dunn's on rules for rectangular slabs, and the other appendices are referred to above.

CONCLUSION.

This second report is in every way an improvement upon the first, and does the Committee credit. It is useful, as we said at first, and if it is interpreted in a liberal spirit, will be valuable as a limited means of appeal, but it should be interpreted into practice by well-trained and experienced designers, who should be permitted to take liberties with it.

INSTRUCTION IN REINFORCED CONCRETE AND STRUCTURAL ENGINEERING.

Until recently no adequate course of instruction was available for students of reinforced concrete, but last winter the deficiency was repaired by the establishment of classes at the London County Council School of Building, Ferndale Road, Brixton, S.W., the lecturer being Mr. H. Kempton Dyson, the Secretary of the Concrete Institute. The course was a very complete one, and the demand for such instruction resulted in a large attendance and necessitated an extension of the scheme, an elementary theory class being formed and two assistant teachers appointed.

As the result of the experience last session the scheme of instruction has again been extended and the scope enlarged for next session, which commences on September 18th. Although the London County Council made a special grant for the purchase of urgently needed apparatus and tools for the practical instruction, these were only received late in the session, but this year many more testing appliances, tools, etc., have been added, and a more systematised course of construction will be possible this session.

Though the subject of reinforced concrete is taught in many places abroad, the course at the School of Building is distinctive in respect to the great feature made of practical work, which is of the utmost importance to a knowledge of theory and the proper execution of the work. Those who seek to design work are required to take both the practical and theoretical instruction, but the practical part is so arranged that it can be taken independently by builders, clerks of works, foremen, craftsmen, and others who only wish to study that aspect. It is to be hoped that the practical workers will avail themselves of the opportunity, for there is a most regrettable ignorance of the proper methods of carrying out concrete work displayed in building work in this country.

As an outcome of the establishment of this class for reinforced concrete, the need was ascertained of a more extended field of operations. Reinforced concrete design is a branch of structural engineering, and for its proper study requires a knowledge of applied mechanics and the design of various kinds and parts of structures. Structural engineering is becoming a specialised subject, and therefore this session a complete course of instruction therein has been framed extending over four years, in which various other classes at the school have been utilised in the preliminary stages, and the opportunity will be taken in giving the necessary instruction in the principles of structural design, to show their application to all constructive materials. This, while a necessary part of reinforced concrete instruction, is to be so arranged as to appeal to those who desire to obtain a knowledge of the higher theory of structures. This branch also will be distinctive, because the practical design of structures will be demonstrated, including such subjects, for instance, as heavy timberwork, bins, foundations, piles, reservoirs, tanks, pipes, culverts, bridges, statically indeterminate structures, fire-resisting construction, architectual acoustics, etc. The last two named are specially noteworthy, and the lecturer will impart much original information. To supplement the foregoing a class will be formed to give practice in the drawing and design of structures in reinforced concrete and steel. This class will be conducted on the lines of a drawing office.

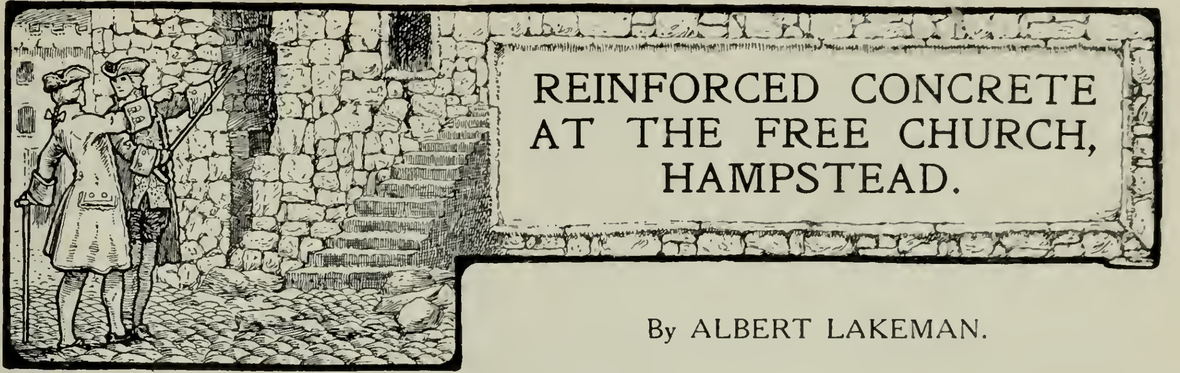
The details of the course are given in our Memoranda, and we would only add one suggestion, and that is the arrangements be such that district surveyors and other men of mature age may have certain facilities and certain seats reserved for them, that if they be desirous of learning, they need not be seated side by side with the younger students. In Germany special seats are reserved for officials and others desirous of keeping themselves posted in educational work originally planned for juniors, and the facilities accorded are appreciated by the controlling authorities who realise that their officers must keep " up-to-date."

ELECTROLYSIS AND REINFORCED CONCRETE.

The American Technical press is according considerable attention to damage caused in buildings by electrolysis.

We are collecting data, as the matter is of some importance to the designers and users of reinforced concrete.

Any cases that have come to the knowledge of our readers would be welcome, and if desired would be dealt with in our columns without mention of location, owners or construction.



REINFORCED CONCRETE AT THE FREE CHURCH, HAMPSTEAD.

By ALBERT LAKEMAN.

The use of reinforced concrete in ecclesiastical buildings is still somewhat of an exception, but its application for this purpose is on the increase. The example here presented will, therefore, be of interest to our readers.—ED.

THIS church is now being erected at Hampstead, in the Garden Suburb, from the designs of Mr. E. L. Lutyens, F.R.I.B.A., and it will be capable of seating nearly 1,000 persons, exclusive of the gallery appropriated to the choir, and in addition space is found for a choir-room, church parlour, and various offices. The elevations are striking, and possessed of a character which will render the building in keeping with its surroundings, with the high-pitched roof and brick dressings, as shown in *Fig.* 2

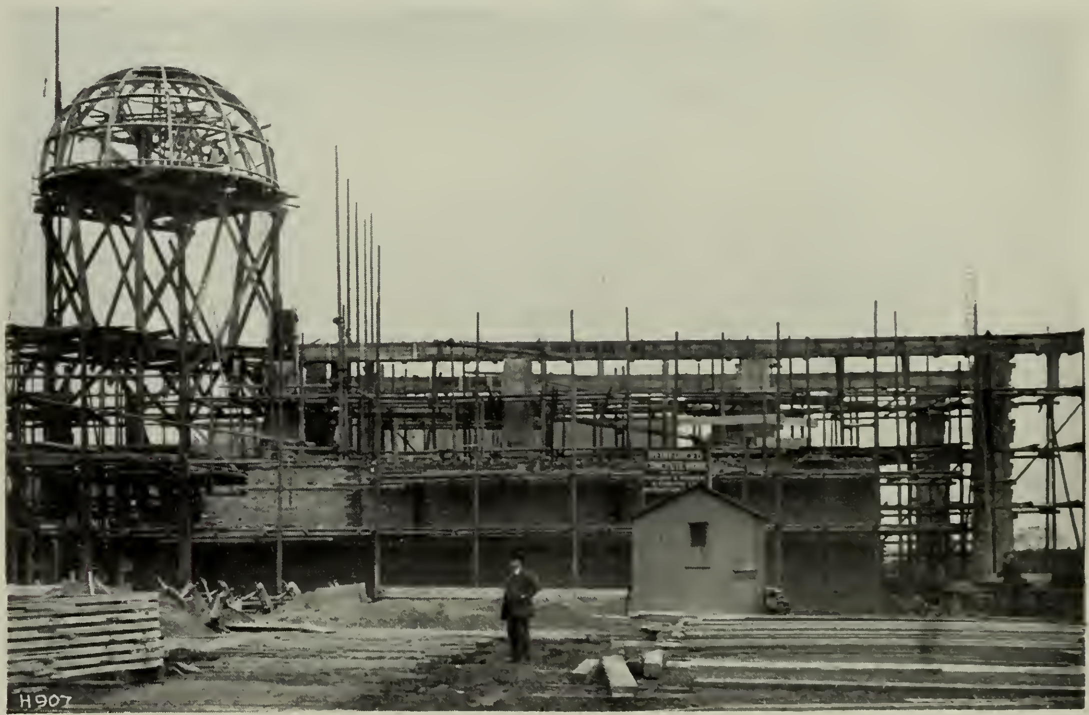


Fig. 1. Centering for Inner Dome.
REINFORCED CONCRETE AT THE FREE CHURCH, HAMPSTEAD.

It is interesting on account of the fact that the constructional weight-carrying members are designed in reinforced concrete, these consisting of columns, beams, and domes.

On reference to the plan illustrated in *Fig.* 3, it will be seen that the nave is divided into a main and side aisles by a row of columns, four on each side. These columns are about 28 ft. high, and, with the exception of those under the dome, the lower 9 ft. is 2 ft. 9 in. square, whilst above this the column is circular. The reinforcement in the lower portion consists of four $\frac{7}{8}$-in. square bars in the corners and eight similar bars spaced equally on the circumference of an internal circular cove, having a diameter of 1 ft. $9\frac{1}{2}$ in., and these latter are carried straight up to form the reinforcement for the upper circular part of the column, the square bars in the corners of the lower portion being bent into the circular portion and carried well up. The hooping is provided in the form of $\frac{1}{4}$-in. square links spaced at 12-in. centres. The foundation under each column consists of a

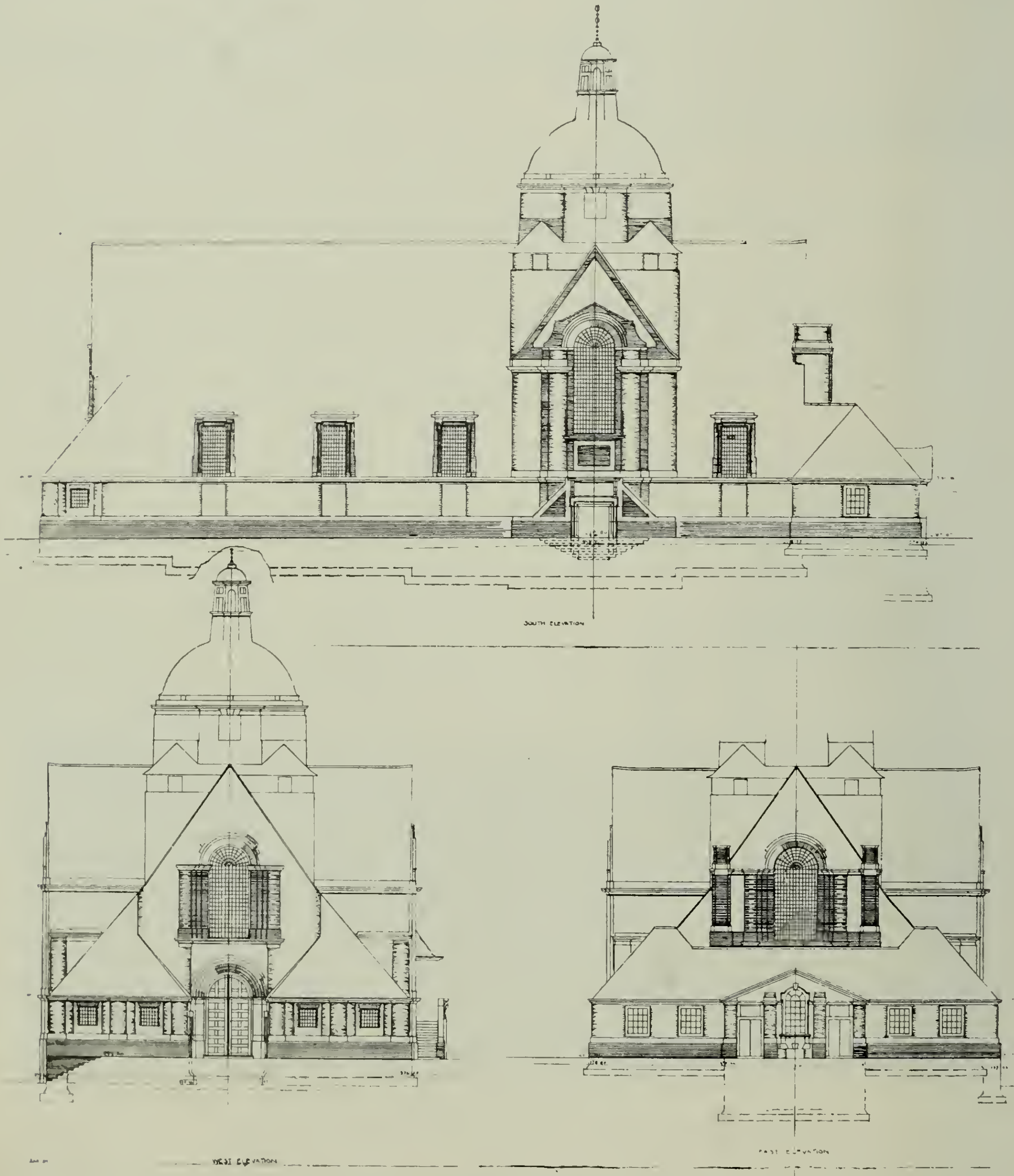


Fig. 2. Elevations.
REINFORCED CONCRETE AT THE FREE CHURCH, HAMPSTEAD.

concrete base 8 ft. by 5 ft., having square sides for a height of 1 ft. 3 in., and above this the concrete is splayed back to meet the size of the column. The reinforcement consists of $\frac{15}{16}$-in. diameter rods at 12 in. centres, and $\frac{3}{4}$-in. cup bars at right angles to the latter and spaced at 7-in. centres.

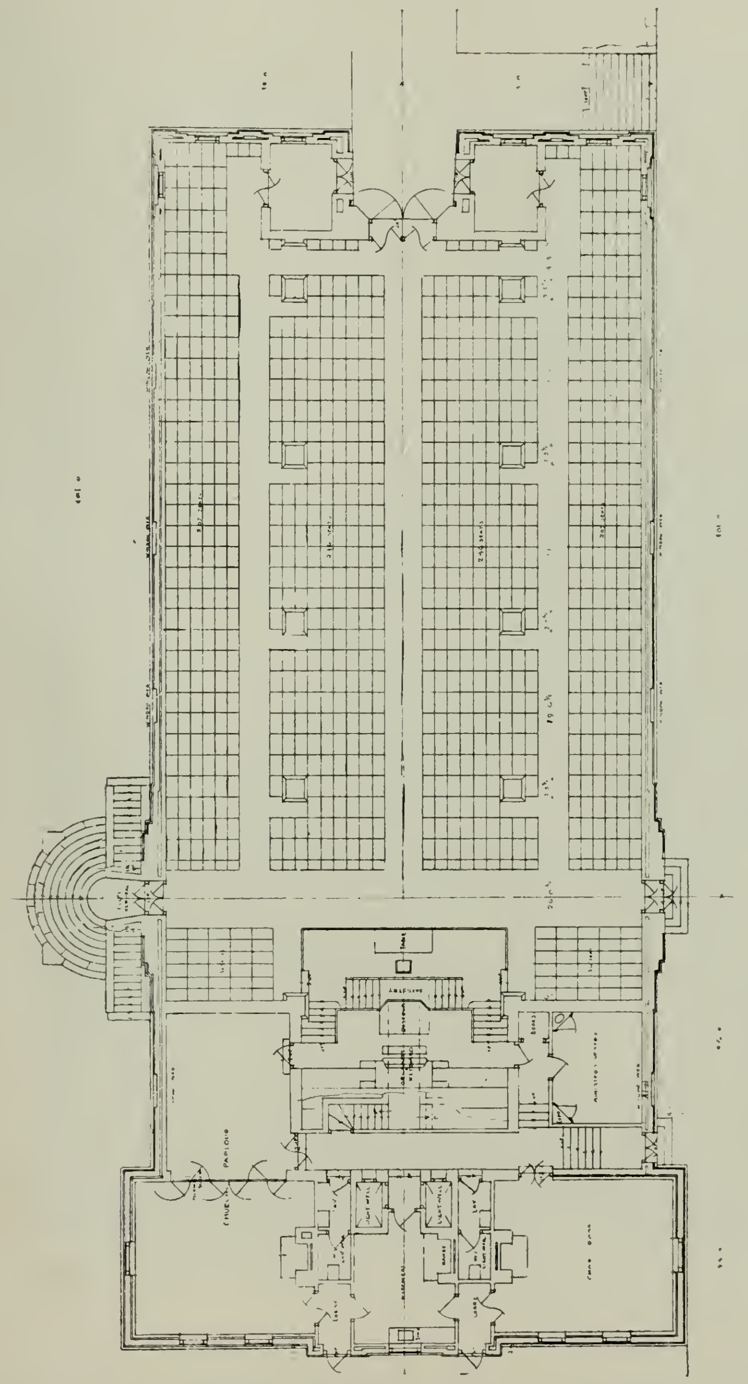


Fig. 3. Ground Floor Plan.

Reinforced Concrete at the Free Church, Hampstead.

These columns are spaced at 22-ft. centres along the lines of the central aisle, which is 28 ft. 6 in. wide. Concrete beams 18 in. by 18 in. are carried on these columns, having a span of 22 ft., and being reinforced in the upper surface with eight $\frac{3}{4}$-in. cup bars, and in the lower surface with eight $\frac{7}{8}$-in. square bars, the latter being bent up at the ends to resist shear. The two sets of reinforcement are connected with $\frac{1}{4}$-in. diameter rods bent round them at distances from 6 in. to 12 in. The connection between the beams and the head of the columns is augmented in each case with four bars $\frac{15}{16}$-in. diameter, having a length of 3 ft. These beams are illustrated in the detail drawing shown in *Fig.* 8.

The columns carrying the dome, which are illustrated in *Fig.* 5, are similar in height to those previously described, but they are 2 ft. 4½ in. square in the upper portion, while the lower 9 ft. is increased to 2 ft. 9 in. square. The disposition of the reinforcement is shown in the illustration, and it consists of eight $\frac{7}{8}$-in. square bars with $\frac{5}{16}$-in. diameter links at every 6 in. Four extra bars are inserted in the corners of the lower portion where the increased size occurs. The concrete foundation for these columns is constructed with a slab 9 ft. square, having vertical sides for a height of 12 in. from the bottom, with a splay above this point to meet the size of the column 2 ft. above. Reinforcement is provided in the form of $\frac{7}{8}$-in. bars spaced at $10\frac{1}{2}$-in. centres, with three stirrups at each end of every bar not crossing the mitre line of the splay at the corner.

The columns under the dome are connected by concrete arches having a rise of about 13 ft., and a depth at the crown of 4 ft. 6 in. These have a thickness of 2 ft., with reinforcement as indicated on the drawings of this portion illustrated in *Fig.* 6. The inner dome, which has a radius of about 13 ft. and a rise of about 12 ft., is carried from these arches, and the plan is brought from the square to an octagonal shape by beams 4 ft. 6 in. in depth and 2 ft. thick, which cut off the angles above the pendentives, the latter being formed with a minimum thickness of 4 in. of concrete reinforced with expanded metal. The beams are reinforced with

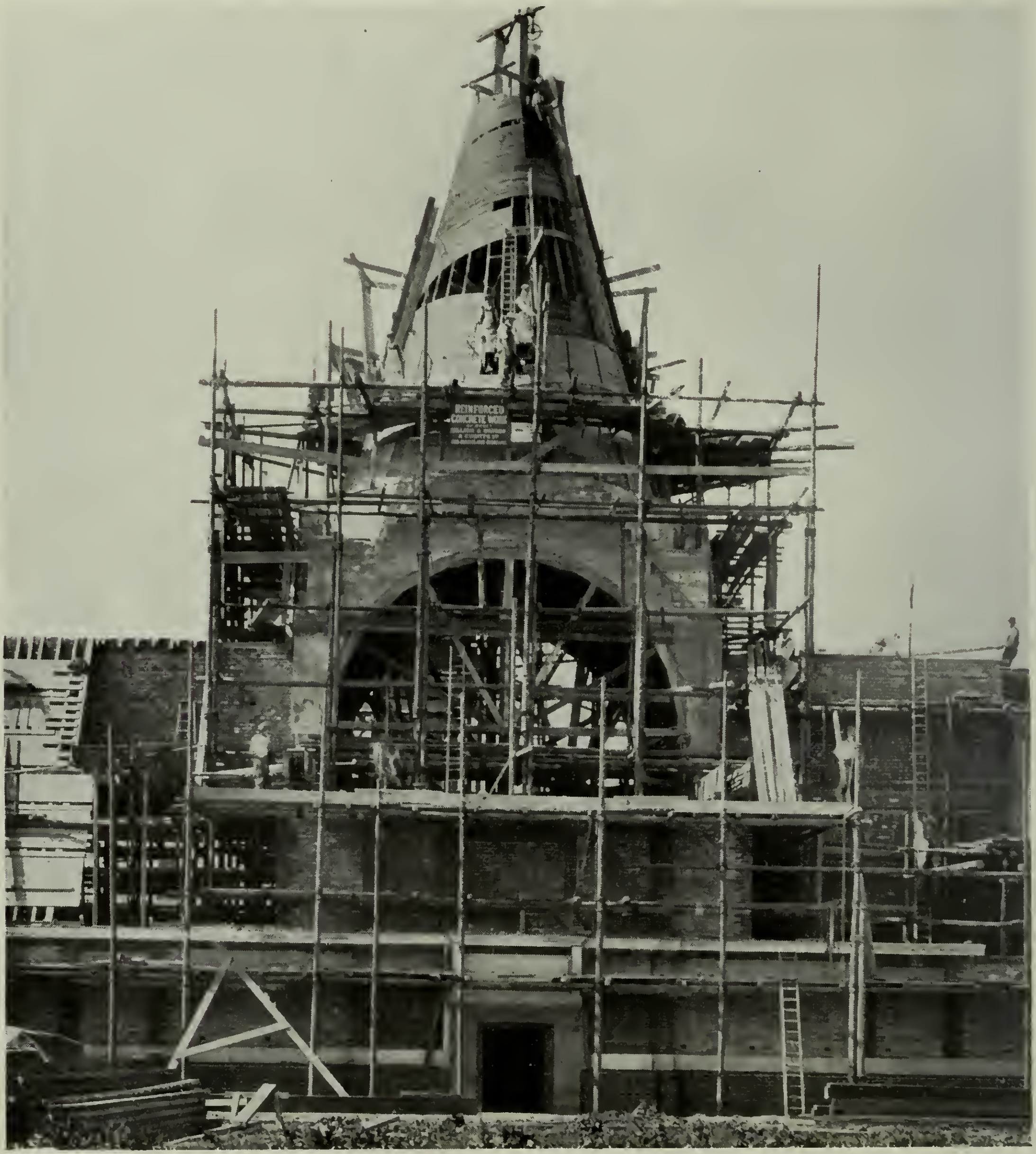


Fig. 4. Centering for Concrete Cone.
REINFORCED CONCRETE AT THE FREE CHURCH, HAMPSTEAD.

two $\frac{7}{8}$-in. and two $1\frac{1}{8}$-in. rods in the lower surface, and two $\frac{3}{4}$-in. cup bars in the upper surface, with $\frac{1}{4}$-in. links at 12-in. centres round both sets. The dome itself

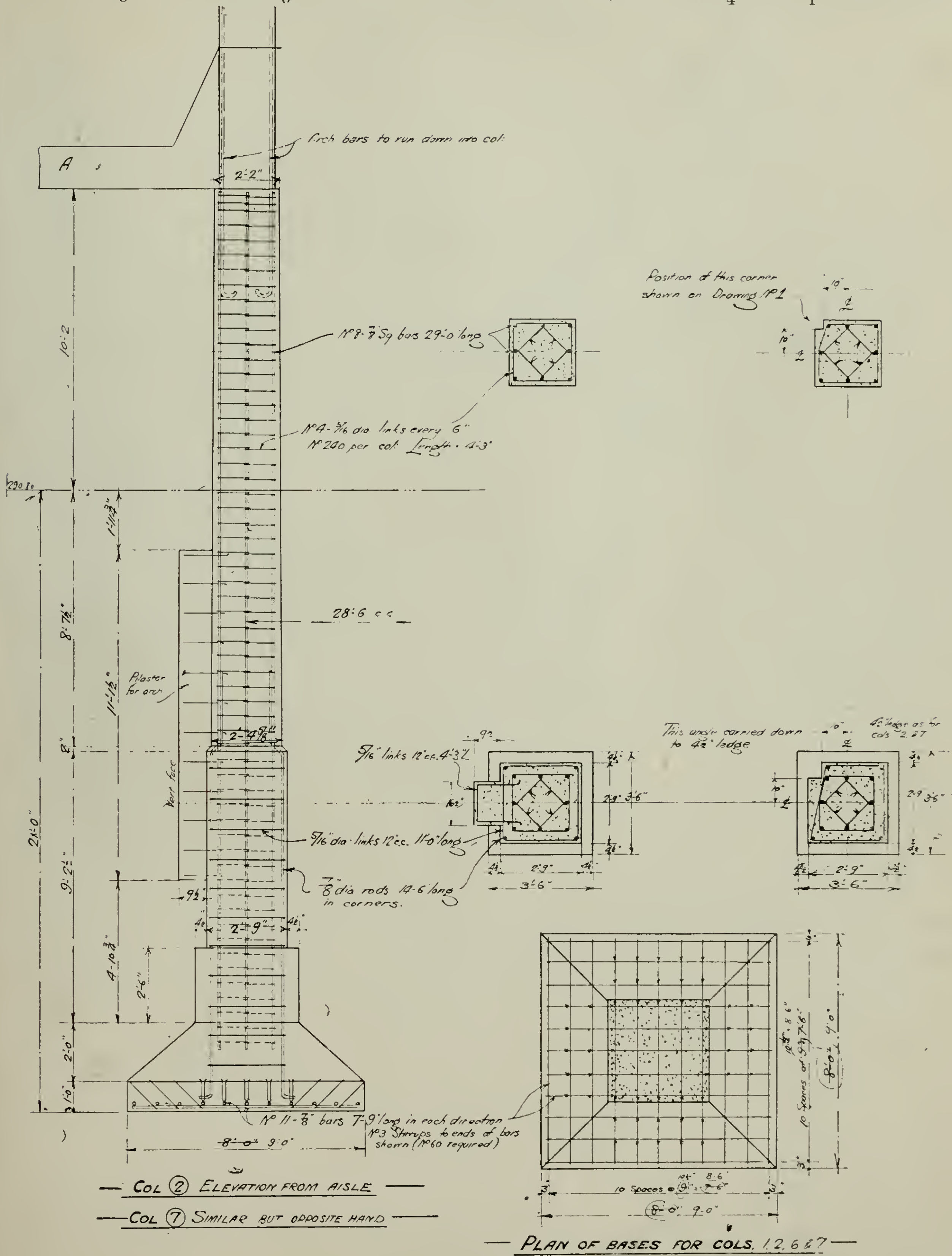

Arch bars to run down into col:
A
2'-2"
10'-2
No 8 - 7/8" Sq bars 29'-0" long
No 4 - 5/16 dia links every 6"
No 240 per col: Length 4'-3"
290.80
1'-11¾"
8'-7½"
28'-6 c c
Pilaster for arch
11'-1½"
2'-4⅝"
8"
Vert face
21'-0"
9'-2½"
9½"
4½"
2'-9"
4'-10¾"
2'-6"
2'-0"
1'-0"
5/16" links 12" c.c. 4'-3"
5/16" dia links 12" c.c. 11'-0" long
7/8" dia rods 14'-6 long in corners.
9½
2'-9"
3'-6"
4½"
No 11 - 7/8" bars 7'-9" long in each direction
No 3 Stirrups to ends of bars shown (No 60 required)
~~8'-0"~~ 9'-0"
COL ② ELEVATION FROM AISLE
COL ⑦ SIMILAR BUT OPPOSITE HAND
Position of this corner shown on Drawing No 1
10"
This angle carried down to 4½" ledge
4½" ledge as for cols 2 & 7
10 Spaces @ 9" = 7'-6"
10 Spaces of 9" = 7'-6"
8'-6"
3"
~~8'-0"~~ 9'-0"
PLAN OF BASES FOR COLS. 1, 2, 6 & 7

Fig. 5. Details of Columns under Dome.

Reinforced Concrete at the Free Church, Hampstead.

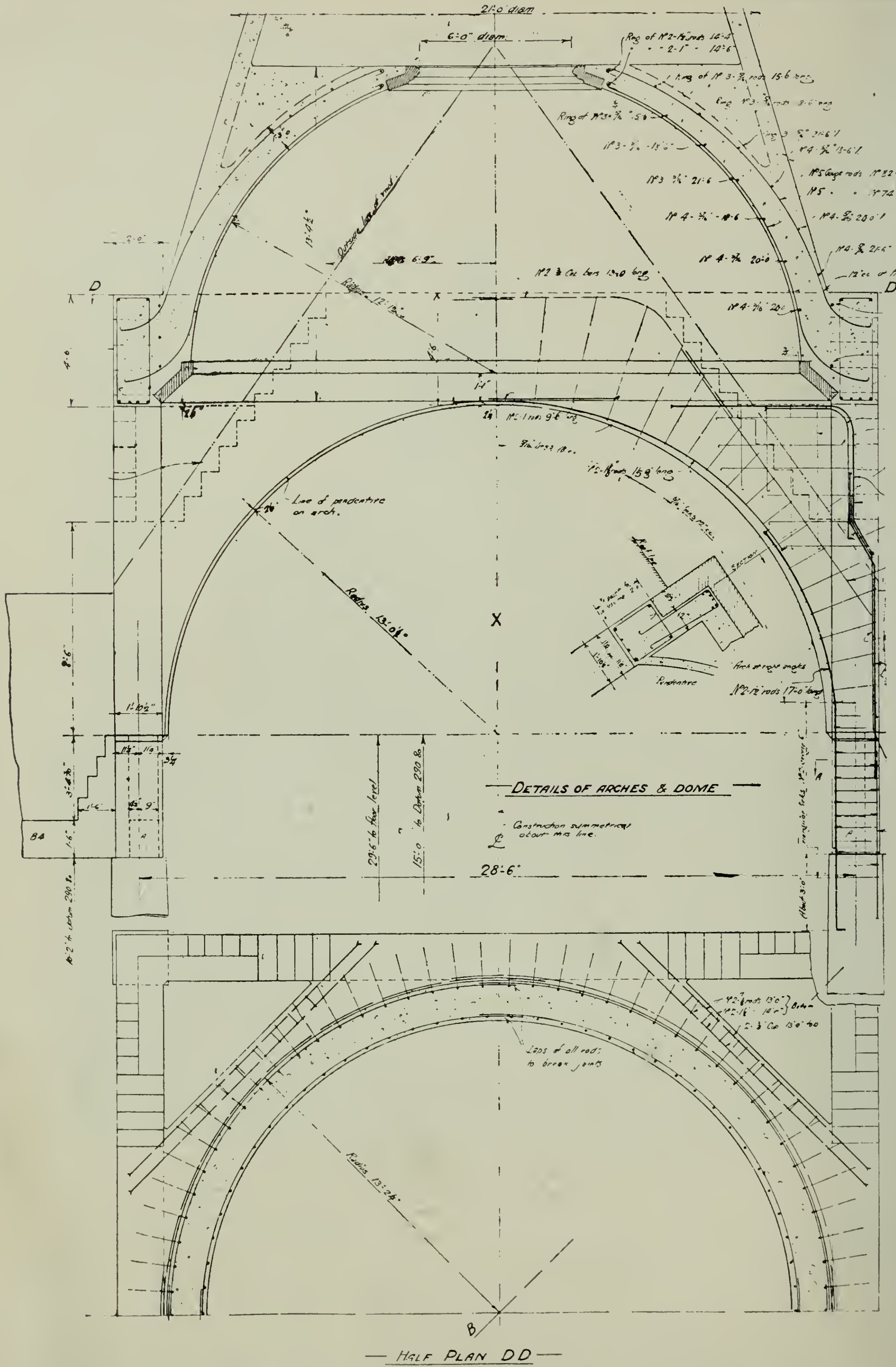


Fig. 6. Details of Inner Dome, Arches, and Pendentives.
REINFORCED CONCRETE AT THE FREE CHURCH, HAMPSTEAD.

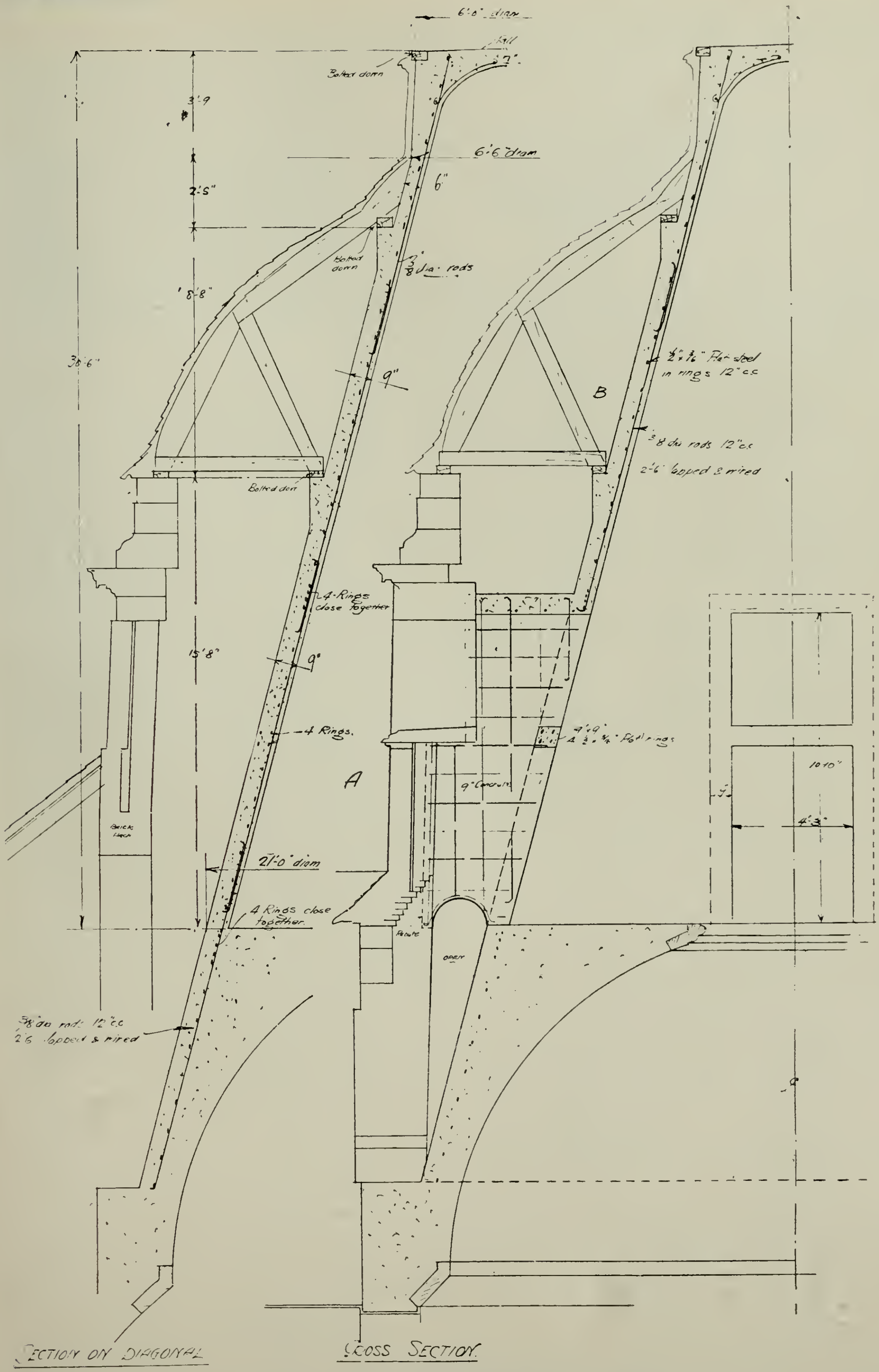


Fig. 7. Details of Concrete Cone and Outer Dome.
Reinforced Concrete at the Free Church, Hampstead.

has a central opening 6 ft. in diameter, and the ring round this is formed with two $1\frac{1}{8}$-in. rods and two 1-in. rods, while the reinforcement in the main portion consists of $\frac{5}{16}$-in. diameter circumferential rods in the upper and lower surfaces placed alternately at 12 in. apart, and similar radial rods spaced at 12-in. centres at the springing. The photograph in *Fig.* 1 illustrates some of the centering in position for this dome and the beams. An interesting piece of construction is that between the inner dome just described and the outer dome which is built up with timber framing, this latter being supported by reinforced concrete in the form of the frustum of a cone 30 ft. 6 in. high, having a diameter of 6 ft. at the top and 21 ft. at the point where it leaves the inner dome. Some idea of this piece of construction can be gathered from the photographic view shown in *Fig.* 4, which illustrates the shuttering necessary at this point. The concrete is 9 in. thick, and it is reinforced with radial rods $\frac{3}{8}$-in. diameter spaced at 12-in. centres at the base, and circumferential rods $\frac{1}{2}$ in. by $\frac{3}{16}$ in. flat at 12-in. centres generally. Four openings occur in the lower part, each 4 ft. 3 in. wide and 10 ft. 10 in. high, and these have 9 in. by 9 in. concrete transoms reinforced with four $\frac{1}{2}$-in. by $\frac{3}{16}$-in. flat rods. The rods in the cone are carried down on the outer side of the inner dome, forming a connection between the two, and giving monolithic construction. The details of this portion are illustrated in *Fig.* 7. The Cubitt Concrete Construction Co., of Gray's Inn Road, were responsible for the execution of this portion of the building.

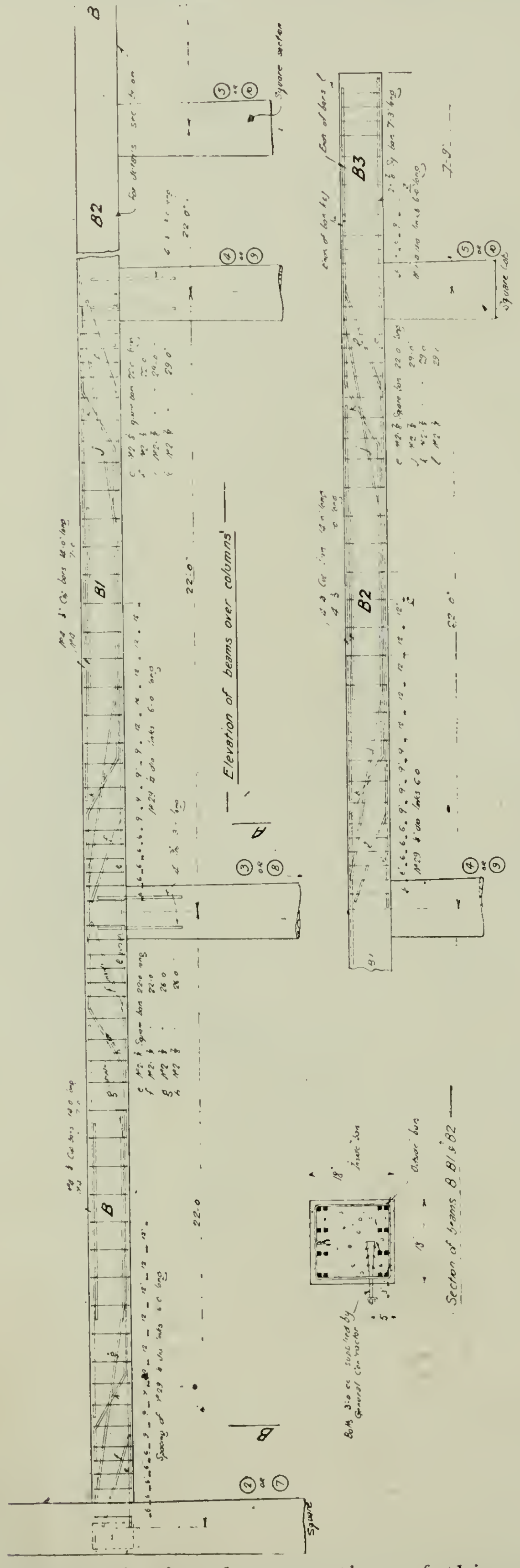


Fig. 8. Details of Beams.
Reinforced Concrete at the Free Church, Hampstead.

CONCRETE ENGINEERING (THEORETICAL).

By A. C. DAVIS, F.C.S., Assoc.Inst.C.E.

In our last issue we published the text of Mr. A. C. Davis' lecture on the practical side of concrete engineering, and in the current number we give his discourse on the theoretical side. Both these lectures were delivered by Mr. Davis at the University of Cambridge.—ED.

Reinforced concrete construction in engineering practice consists, as has been previously explained, of a combination of concrete and steel so placed relatively to each other that the steel takes up the tension strains whilst the concrete withstands the compressive stresses.

ADVANTAGES OF REINFORCED CONCRETE.

The reason for distributing the stresses and strains in this manner between the two materials is primarily a matter of economy.

The cost of reinforced concrete construction, although higher than that of timber, compares very favourably with steel structures. The initial cost, however, must not alone be considered. It is estimated that the elimination of painting and maintenance expenses alone justifies an additional increased cost of from 10 to 15 per cent. over the cost of steel construction.

The saving which has been obtained by H.M. Office of Works in its public buildings has been officially stated to be 20 per cent., as compared with other methods of construction.

This saving in cost does not however fully represent the advantages of the use of concrete in compression, for the reasons shortly to be stated.

No comparison can be made between the cost of concrete and steel in tension. Concrete is quite unreliable when used in this manner, and although it may be expected to withstand a tension stress of 400 lb. per sq. in. under loads which are gradually applied, its liability to sudden fracture from temperature stresses and suddenly applied loads has necessitated any resistance to tension which it may possess being entirely disregarded in engineering structures.

Apart from the relative cheapness of concrete when used in compression, and of steel when used in tension, the advantages of the combination of the two materials may be summed up as follows.

The steel is held firmly in its place, and therefore long thin lengths can be compressed without lateral distortion. It is entirely preserved from oxidation by the alkaline properties of the concrete which surrounds it. Rust being thus prevented, periodical painting of the steel is rendered unnecessary, and the maintenance charges of the structure become negligible.

A further advantage of the combination of steel and concrete is that the steel is rendered fireproof by the non-conductivity to heat of the concrete which surrounds it.

The use of these two materials forms, perhaps, the most fire-resisting combination at the disposal of engineers. Even if a moderate portion of the heat from a fire did penetrate the concrete, little harm is done. The respective coefficients of expansion of steel and concrete are identical, or nearly so, and any internal strains set up through temperature variation are not sufficient to destroy the bond between the two materials.

In examining the theory of reinforced concrete construction the two principal members which we should consider are the beam subject to transverse stresses under a load and the column taking a direct compression.

BEAMS.

In a plain rectangular beam, which is shown in section in *Fig.* 1, it is usually assumed that the coefficient of elasticity in compression is the same as in tension, and that the neutral axis where the forces change from compression to tension is midway between the top and bottom of the beam. The stress intensity on the fibres of the beam varies directly with their distance from the neutral axis.

These stresses may be conveniently shown in the form of the shaded triangles in this *Fig.* 1, the width of the shading at any distance from the neutral axis being proportional to the stress at that point. In calculating the bending moment which such a beam will resist, it is necessary to find the centre of gravity of each of the triangles and to determine their distance apart. Very little consideration of geometrical laws shows us that the centre of the upper triangle is at a point one-third of the perpendicular distance down the upper triangle, or one-sixth of the total depth of the beam. Similarly, the centre of tension is one-sixth of the depth from the extreme lower fibres. With the deduction of these two-sixths of the distance, it necessarily follows that the distance apart of the centres of compression and tension is two-thirds the depth, and to obtain the moment of resistance of the beam the maximum stress of the material within the triangle is multiplied by two-thirds the depth.

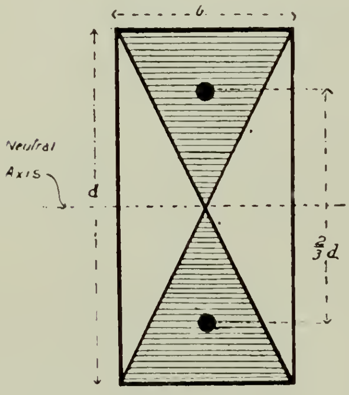


Fig 1

In reinforced concrete, however, the case is not so simple as this; a reinforced beam is a discrete beam. The coefficient of elasticity of concrete is not the same as that of the steel, and the neutral axis is not midway between the top and bottom of the beam.

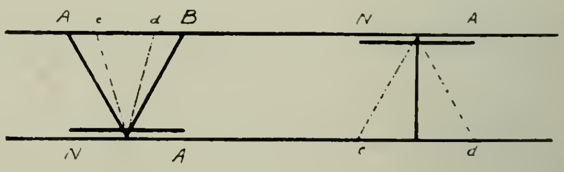


Fig 2

The movement of the neutral axis up and down the depth of the beam may be illustrated by assuming extreme cases. Let it be assumed that the area of *steel* used in the reinforced concrete beam is so great that it becomes practically *inextensible*, and that under the weight applied the concrete is crushed up. This is illustrated in *Fig.* 2. The points *AB* (*Fig.* 2) are crushed up together into the position shown by the dotted lines. It will be seen that the whole of the concrete is in compression, and that the neutral axis is low down in the beam just above the steel. Take the other extreme in which the section of steel is so small that it stretches under the applied weight as in the case of elastic. A vertical line on the side of the beam opens out as at *CD*. If the concrete refused to be compressed, the strain would be taken by the top fibres, the concrete below this point would follow the steel by opening out, and the neutral axis would be near the top of the beam.

Between these two practically impossible extremes it will be seen that the neutral axis moves up and down the beam, and that its position varies with the amount of steel and its elasticity, and also with the amount of concrete and its elasticity.

Before any calculation of the moment of resistance of a beam can be made, it is therefore necessary to locate the neutral axis. The coefficient of elasticity of concrete is a variable quantity, as is also that of steel. In the latter case, however, so much experience in manufacture has been obtained that an engineer may specify the elasticity of the steel he desires to use, and may rely with every confidence in obtaining it. As a rule, mild open-hearth steel with a coefficient of elasticity of 30,000,000 lb. per sq. in. is used.

The coefficient of elasticity of concrete varies with the quality and quantity of cement used, with the character of the aggregate, with the age of the concrete, and with the stresses to which it is subjected.

The limits of this variation are roughly between 3,000,000 lb. and 1,500,000 lb. per sq. in. Modern practice in reinforced concrete design places the coefficient of elasticity of concrete at 2,000,000 lb., which is the average result obtained with concrete, made with 4½ parts or 5 parts of good hard stone and sand aggregate to 1 part of cement.

Steel has therefore 15 times the elastic resistance of concrete, and the *greater* the amount of steel used the *lower* the neutral axis is found. In practice, however, but a small proportion of steel is used—about 1 per cent., and the total elasticity of this small quantity is greater than the total elasticity of the concrete. The neutral axis is therefore *above* the centre line of the beam, and is, as a matter of fact, about two-fifths of the depth from the top (*Fig.* 3). The use of 2 per cent. of steel brings the neutral axis approximately to the centre.

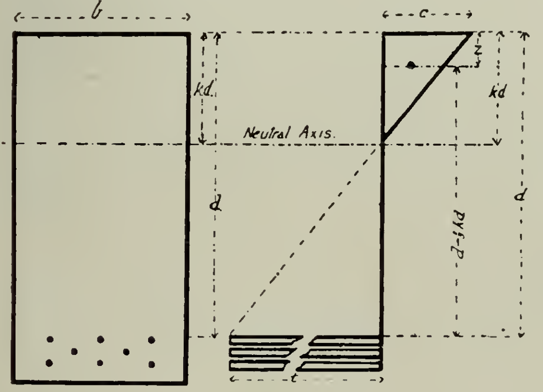


Fig 3

Turning to the notes and formulæ, a method of ascertaining the proportionate depth of the neutral axis will be found in formula numbered (3) in the Appendix hereto, k represents the depth of the neutral axis, where P is the proportion of metal to concrete, and m the ratio of elasticity of the two materials.

I have not given the full working out of the equations, as such working involves merely a knowledge of the simple algebraical rules. Sufficient information is, however, given to enable the full working to be carried out in private study.

Formulæ for ascertaining the tension on the steel and the compression in concrete are shown numbered (5) and (6) in the Appendix. Immediately above these equations is set out the moment of resistance of the beam (Formula a). Let us take first the moment about the centre of compression. This consists of the total tension on the steel multiplied by its distance from the centre of compression in the concrete. The total tension in the steel is the product of the area of the steel, A_t, and the tension per square inch, t. The distance from the centre of compression is $d-\frac{1}{3}kd$, and is shown in *Fig.* 3. The depth of concrete in compression down to the neutral axis is kd. The stress diagram of the concrete is triangular, exactly as it is in an ordinary rectangular beam. In the same way the distance of the resultant thrust from the top of the beam is one-third of the depth to the neutral axis. The total distance from the steel to the centre of compression is therefore $d - \frac{1}{3}kd$. This is equivalent to the expression two-thirds d in the case of the ordinary rectangular beam shown in *Fig.* 1.

In taking the total compression in the concrete, it will be noticed that only half the area of concrete is considered and shown as $\frac{1}{2}A_c$ in Formula (a). This is due to the compression on the concrete varying from nothing at the neutral axis to the maximum at the top fibres, exactly as in the case of ordinary rectangular beams, with the principles of which you will be acquainted.

Formulæ (5) and (6) follow naturally from those which precede them, and the full working out can be done at leisure.

It will be seen by an inspection of numbers (5) and (6) that the tension on the steel per square in., t, and the compression in the concrete, c, both vary directly with the bending moment, M. If the bending moment, M, were doubled, the tension, t, would be doubled, as likewise would the compression, c. It follows, therefore, that if the correct proportion of steel were used in the manufacture of a concrete beam, and if such a beam were loaded until it failed, the concrete and the steel would both be stressed to their utmost, and would fail at the same moment. If too much steel were used the concrete would fail. If too little steel were used the steel would fail first.

The proportion of steel which will exactly balance the concrete under stress is known as the "economic ratio" of reinforcement. This ratio is worked out in equations (7) to (12). In No. 12 it will be seen that when a reinforced concrete beam contains about 0·7 per cent. of steel in tension, both the steel and concrete are stretched to their utmost under a breaking load. The neutral axis is shown by equation No. 9 to be 0·36 down the depth of the beam. In actual practice it is general to reinforce with a somewhat greater proportion of steel, usually from 1 per cent. to 2 per cent. The result is that, through the rigidity of the steel being increased, the neutral axis is moved lower down the beam and a greater area of concrete is put into compression. The beam is stronger for a given section, but the concrete is weaker than the steel, and will fail first under a breaking load.

In engineering books a convenient formula for the strength of rectangular beams is put in the form of Cbd^2, where C is a constant, varying with the quality and kind of material which is to be used in the beam.

A similar formula with reference to reinforced concrete beams is given in No. 15 of the Appendix. By simply varying the proportions of depth and breadth any number of beams can easily be designed to resist a given bending moment. Where the depth of the beam is limited by local conditions the breadth necessary to take the load can readily be found from the formula. Where the breadth is limited the depth can be ascertained.

It should be remembered that throughout these formulæ the depth mentioned is the effective depth from the top of the beam to the centre of gravity of *the steel* reinforcement as seen in *Fig.* 3. In actual practice the beams will be of greater depth than indicated here. From 1 in. to 2 in. of concrete should be placed below the steel as a fire protection, while in floor slabs this thickness can be reduced to $\frac{1}{2}$ in.

Shear Stress in Beams.—Having now considered how the bending moment of a loaded beam is to be met by embedding steel near the bottom of the beam, it is necessary to consider the question of shear.

If a long beam reinforced only at the bottom is loaded to breaking point, it will not fail at the centre through bending, but near the supports through shear. The load above and the supports below act as the two blades of a pair of shears, and break through the concrete.

The matter of shear is complicated by the bending moment of the beam. The bending moment acts *horizontally* while the shear acts *vertically*. If these two components, say in tension, be blotted out, the direction of the resulting stresses can be shown diagrammatically, as in *Fig*. 4. The curves show the direction of the tensile stresses under the load. Shear is greatest at the ends of the beam, and as the direction of the shear is here perpendicular, the lines approach that position at the ends of the beam. Bending stresses, on the other hand, are greatest at the centre, and are horizontal in direction, as shown by the lines.

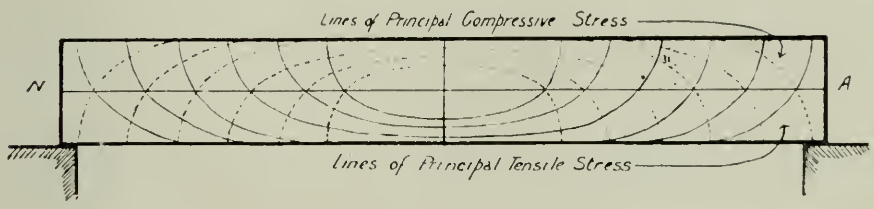

Lines of Principal Compressive Stress
N
A
Lines of Principal Tensile Stress

Fig 4

The concrete which is not relied upon to withstand tension is strained in the direction of the lines, and if not prevented will break at right angles to such lines.

At the bottom of the beam it will be seen that the lines follow the direction of reinforcement for bending moment; but at the ends, where the lines curve into the perpendicular position, further steel must be inserted to carry the strains down to the main tension bars and form a strengthening web connecting the top compression layers of the beam with the bottom. These members, known as shear members, follow closely upon the lines of tension if placed at an angle of 45° with the main tension bar. They may also run up vertically from top to bottom of the beam in the form of stirrups. In this case, although the vertical stirrups do not follow so closely the lines of tensile stress, the defect may be remedied by placing them more closely together.

A reliable method of calculating diagonal tension in a concrete beam cannot be given. We have to deal with a combination of horizontal stress and vertical shear, and the former of these two components is indeterminable. The practical solution of this difficulty is to neglect the horizontal stresses in the concrete and to reinforce for shear only. It therefore follows that since the shear is greatest at the ends of the beam, the web reinforcement will be greatest at the ends, and will gradually diminish towards the centre.

The method of fixing the web or shear reinforcement to the main tension bars varies considerably, and in many cases forms the chief talking point of the many proprietary and patented systems of reinforced concrete construction now upon the market.

In the Hennebique system stirrups, in the form of the letter "U," are placed round the bars at varying distances and extend vertically up into the concrete. In the Kahn system two webs are rolled, one on each side of the main bar. These webs are sheared through at the factory, but left connected to the bar for a small portion of their length. The free end is then turned upwards at an angle of 45°. In the Perfector bar a web underneath the main bar is slotted in such a way that the shear reinforcement may be threaded through the slot, and so held in position.

Another way of reinforcing against shear is to use a comparatively large number of main tension bars in the bottom of the beam, and to turn up to the top of the beam several of the bars at varying intervals to form shear members.

The *adhesion* of concrete to metal is usually taken at 100 lb. per sq. in., and a little consideration will show that, if the ultimate stress of the steel is taken at 15,000 lb. per sq. in., a 1-in. round rod requires a length of 37½ in. buried in the concrete in order that the adhesion of the two materials may be equivalent to the ultimate load on the rod. As the surface of the rod, and therefore its adhesion per lineal inch, is proportional to its diameter. it follows that a ¼-in. rod will be efficiently anchored in one quarter of the above length, or only 9·37 in. Smaller rods, therefore, give better adhesion, and those of large diameter should be bent or split at the ends to provide a secure anchorage in the concrete and prevent slipping.

In spite of the fact that the largest and most important of the European structures in reinforced concrete have been carried out with plain round bars, and that no disadvantage from the slipping of the steel within the concrete has been experienced, American practice leans somewhat towards the use of what are known as deformed bars, which key into the concrete every few inches of their length. In many cases, such as with heavily vibrating floors and those subject to frequent and heavy shock, there is no doubt a considerable advantage attends their use, but there is equally no doubt that plain round and square rods of continuous section throughout are quite equal to all ordinary requirements.

Whilst speaking of patented systems, it may be remarked that one of the earliest systems of reinforced concrete construction adopted in this country was that of the Expanded Metal Company. In this system flat rolled-steel sheets of various thicknesses are cut and expanded by machinery into meshes of a diamond shape, and in this form the sheets are used for reinforcing floor slabs.

A modification of this system is now being introduced in the form of woven wire netting, which is used in one continuous length from one end of a floor to the other.

In *designing* floor slabs with ordinary steel rod reinforcement, it is usual to take a convenient width, say 12 in., and ascertain the load, the depth, and reinforcement as for a rectangular beam 1 ft. wide.

COLUMNS.

Now to come to columns. In calculating the compression stresses upon columns under load, it must be remembered that as steel is much more resistant to compression than concrete, it will take up a greater proportion of the load than is proportional to its area. Where m equals the ratio of the coefficients of elasticity of steel and concrete, the load on the steel will be m times that of concrete per square inch. In practice it is found to be from 10 to 15 times as much.

The stress on the materials can be calculated from Formulæ (16) and (17) which explain themselves. The reason for taking $(m-1)A$ instead of mA is that the area of the steel has already been taken in A, which represents the over-all dimensions of steel and concrete combined.

An important development in the reinforcement of concrete columns is due to M. Considère, who has recently shown that steel rods or wire in the form of *a spiral*, round a column of circular section, has a very marked effect upon the strength of the column. It has been proved that reinforcement in the form of a spiral has *three times* the effect in strengthening the column as a similar quantity of steel placed axially to take the thrust in the direction of its length. The spiral armouring of columns is also an efficient safeguard against the possible effects of defective concrete, as poor concrete strengthened in this manner has been found to be as strong as richer mixtures with similar reinforcement. Concrete heavily armoured with several concentric steel spirals has been known to withstand a weight of 11 tons per sq. in. of section, whereas ordinary concrete will crush at about 1 ton per sq. in.

The elasticity of such columns is very much greater than with concrete reinforced with longitudinal rods. Considère columns have been shortened thirty times as much as plain concrete at its breaking point.

Columns reinforced in this manner are not well able to withstand axial stresses, and a heavy lateral blow while such a column is subject to a heavy load may cause it to fail.

It is therefore advisable to combine spiral with longitudinal armouring, and the diameter of the column should be at least one-tenth of its length, where the limit of pressure is as much as 1,400 lb. per sq. in. If these proportions cannot be maintained the load should be reduced.

When the column and beam are thoroughly understood, the principles of design as in ordinary engineering apply in reinforced concrete.

Truss girders and arches can be designed in the usual way with very little special reference to reinforced concrete.

There are, however, one or two points in design where pure theory is not closely followed, on account of there being found in practice a number of uncertain factors to take into consideration.

CALCULATION OF BENDING MOMENT.

Take the bending moment in beams. A beam uniformly loaded throughout its length, and freely supported at its ends, has for its greatest bending moment, in inch-pounds at the centre, one-eighth of the weight in lbs., multiplied by the length of the span in inches. This is shortly written as $M=\frac{Wl}{8}$.

Few beams are, however, freely supported. Most beams in buildings are partly fixed at their ends, either by being built into walls or through being continuous over several supports. If they are fixed at their ends the greatest bending moment is at the ends, and is $\frac{Wl}{12}$ with tension at the top of the beam. At the centre the bending moment is $\frac{Wl}{24}$. In practice the fixing of the ends must be considered as imperfect or uncertain, and the bending moment at the centre must be calculated at not less than $\frac{Wl}{12}$ instead of $\frac{Wl}{24}$. In this case the moment at the supports will be considerably less than $\frac{Wl}{12}$.

In calculating the bending moment the following points must be considered :

The weight of the materials forming the beam, generally known as the dead load.

The live or accidental load which the beam is to support.

The factor of safety.

The weight of the concrete is 150 lb. per ft. cube. A ready way to remember this is to recall that a foot run of beam weighs the same number of pounds as it has square inches in cross section. Thus a 9-in. by 12-in. beam weighs 108 lb. per ft. run, and is 108 sq. in. in cross section. A 12-in. by 12-in. beam, by this rule, would weigh 144 lb. per ft. run, and be 1 ft. square in section. This is near enough to 150 lb. per cu. ft. for practical purposes.

The live or accidental load depends upon the use to which the building is to be put.

The factor of safety may be allowed for in several ways. One may multiply the ordinary bending moment by the factor of safety, and then design a beam to reach its ultimate strength or just fail under that load, or one may adopt a series of safe stresses and ignore the factor of safety.

In the Appendix hereto the safe tension in steel is given as 15,000 to 17,000 lb. per sq. in., and if the factor of safety is to be ignored, the strain on the steel due to the dead and live loads should lie between these limits.

It will also be seen that the safe stress in the concrete should not exceed 600 lb. per sq. in. in similar circumstances.

If a factor of safety has already been taken into consideration, the stresses of 60,000 lb. per sq. in. for steel and 2,400 lb. for concrete may be used.

APPENDIX.

NOTATION AND FORMULÆ.

M = bending moment in inch-pounds.
t = tension in steel, lb. per sq. in. (S) 15,000 to 17,000 or (U) 60,000.
c = compression in concrete, lb. per sq. in. (S) 500 to 600 or (U) 2,400 to 3,000.
k = proportionate depth of neutral axis.
b = breadth.
d = depth to C.G. of steel.
$A_c = kbd$ = area of concrete in compression.
$A_t = pbd$ = area of steel in tension.
$p = A_t/bd$ = ratio of steel to concrete.
$m = E_s/E_c$ = ratio of coefficients of elasticity in steel and concrete = 30,000,000/12,000,000 lb. per sq. in. = 15.

The figures preceded by (S) = safe stresses, and those preceded by (U) = ultimate *stresses*.

Safe shearing stress in concrete, 60 lb. per sq. in.

Adhesion, *concrete to metal*, 100 lb. per sq. in.

NEUTRAL AXIS IN BEAMS.

On account of the greater rigidity of steel, at a given distance from the neutral axis, the stress per square inch in the steel will be m times as great as in the concrete, or

$$mc : kd :: t : d - kd,$$

$$\therefore c = \frac{kt}{m(1-k)} \qquad (1).$$

But by equating the moments of compression and tension,

$$\tfrac{1}{2}kdbc = pbdt,$$

$$c = \frac{2pt}{k},$$

Replacing c in terms of (1),

$$\frac{kt}{m(1-k)} = \frac{2pt}{k},$$

$$p = \frac{k^2}{2m(1-k)} \qquad (2).$$

$$k = \sqrt{p^2m^2 + 2pm} - pm \qquad (3).$$

An approximate location of k is made by Talbot, based upon experiments on beams :

$$k = {\cdot}26 + 18p \qquad (4).$$

The bending moment due to the load upon a beam is met by the moment of resistance of the beam, which, in its turn, is found by multiplying together the effective area of the steel or concrete, the tension or compression per square inch, and the distance from the opposite point of compression or tension :

$$M = A_t t(d - \tfrac{1}{3}kd) \text{ or } \tfrac{1}{2}A_c c(d - \tfrac{1}{3}kd) \qquad \text{(a)}$$
$$= tpbd^2(1 - \tfrac{1}{3}kd) \text{ or } \tfrac{1}{2}ckbd(d - \tfrac{1}{3}kd)$$

from whence it follows

$$t=\frac{M}{pbd^2(1-\frac{1}{3}k)} \qquad (5),$$

$$c=\frac{2M}{kbd^2(1-\frac{1}{3}k)} \qquad (6).$$

To find the economic ratio p of reinforcement :

since $\quad M=tpbd^2(1-\frac{1}{3}k)=\frac{1}{2}ckbd^2(1-\frac{1}{3}k),$

$$\tfrac{1}{2}ck=tp\ ;$$

substituting $\quad p=\dfrac{k^2}{2m(1-k)}$ from (2),

$$\tfrac{1}{2}ck=\frac{tk^2}{2m(1-k)},$$

$$k=\frac{cm}{t+cm} \qquad (7),$$

$$=\frac{1}{1+\dfrac{t}{cm}} \qquad (8).$$

t, c, and m have known values, being usually 16,000, 600 and 15 respectively,

$$\therefore k=\cdot36 \qquad (9),$$

$$1-\tfrac{1}{3}k=\cdot88 \qquad (10).$$

It was shewn that $\quad \frac{1}{2}ck=tp,$

$$p=\frac{ck}{2t} \qquad (11).$$

And since c, k, and t, are known, being 600, ·36 and 16,000 respectively,

$\therefore$ the economic ratio $p=\cdot00675$ (12),

or approximately ·7 per cent.

The strength of a beam may be put in the form of

$$M=Cbd^2 \qquad (13),$$

where C is a constant for given values of p, t, c, and m.

Since $\quad M=tpbd^2\,(1-\frac{1}{3}k)=\frac{1}{2}ckbd^2(1-\frac{1}{3}k),$

$$=[tp(1-\tfrac{1}{3}k)]\,bd^2=[\tfrac{1}{2}ck(1-\tfrac{1}{3}k)]\,bd^2 \qquad (14).$$

and with values previously given for the economic ratio,

$$M=95\cdot04\ bd^2 \qquad (15).$$

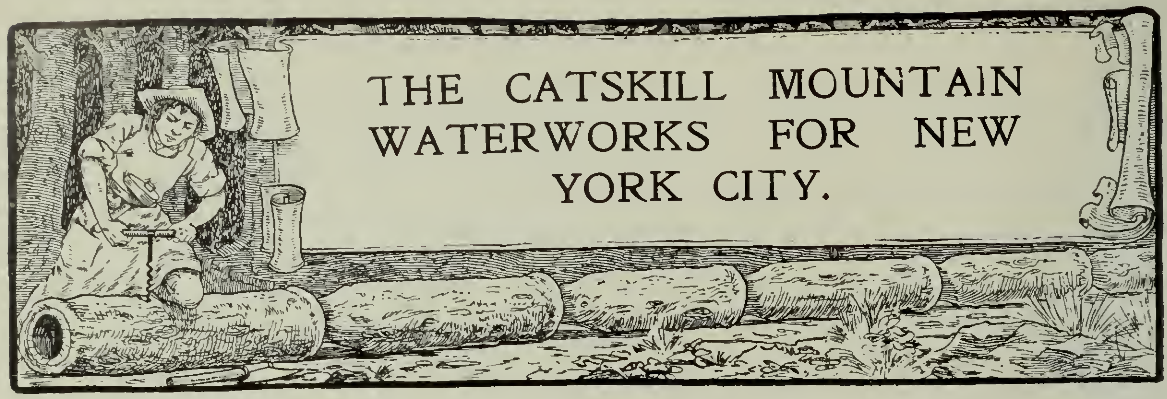
Where p is not in economic ratio, k must be found from (3).

In columns subject to direct loads

$$c=\frac{P}{A_c+ma-a}=\frac{P}{A_c+(m-1)a} \qquad (16),$$

$$t=mc \qquad (17),$$

where A_c=total area of section of the column, a=area of steel placed longitudinally, and P=total load in lbs.



THE CATSKILL MOUNTAIN WATERWORKS FOR NEW YORK CITY.

As in the case of the Panama Canal, the waterworks dealt with in this article afford a remarkable example of the modern application of concrete, concrete masonry ana Portland cement.—ED.

THE Catskill Mountain water project is one of the most stupendous undertakings of its kind, and is second only in importance in American engineering works to the construction of the Panama Canal. It will provide New York with water for at least thirty years, and this notwithstanding the great annual increase in that city's population.

The scheme comprises the Ashokan Reservoir, which is now being built under contracts amounting to nearly £2,800,000, and which will have a capacity of 130,000,000,000 gallons of water, and a surface of 590 ft. above sea level. This reservoir is connected to the city by means of the Catskill Aqueduct, which is to have a daily capacity of 500,000,000 gallons. There are also numerous branch aqueducts and reservoirs, filtration plants and aeration fountains, a delivery tunnel from Hill View Reservoir to the heart of Brooklyn, and large pipe conduits to Queen's and Richmond Boroughs.

THE CATSKILL AQUEDUCT.

This aqueduct, which is to convey the water from the Ashokan Reservoir to the Hill View Reservoir, will be the longest structure of this kind in the world, the total length being 110 miles.

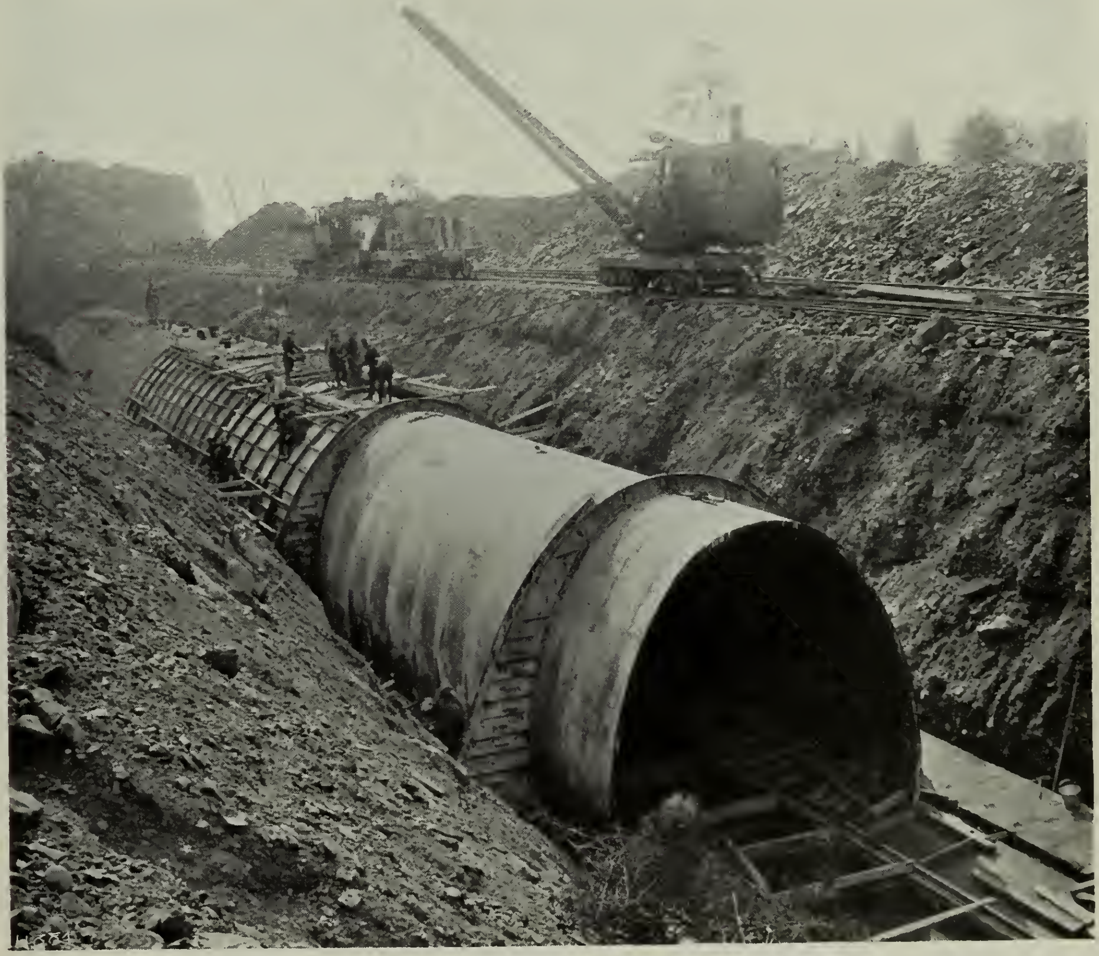
There are four distinct types of aqueduct, cut-and-cover, grade tunnel, pressure tunnel, and steel-pipe siphon, north of the city line.

Cut-and-cover will form 55 miles of the aqueduct, will be of horseshoe shape, 17 ft. high by 17 ft. 6 in. wide inside, and will be constructed of concrete in trench, requiring 4.96 cu. yd. of concrete per linear ft.

This trench did not require pumping, and as soon as the bottom was trimmed the invert concrete was put in in sections 15 ft. long. When the invert concrete was three or four days old the forms for the side walls were erected. These side walls were built to a height of 8 ft., with a tongue and groove joint with the invert. The concrete for the side walls was delivered by steel buckets, which were turned sideways, so as to dump about one-half their contents in the form and the other half on the edge of a working platform on top of the forms, whence it was shovelled in as required. Concrete was dumped direct on the inner form at the crown, and was thoroughly spaded. After the concrete was 24 hours old the outside forms were stripped off, and, after 72 hours, the inside forms were removed.

The total amount of concrete required for this cut-and-cover aqueduct will be 143,000 cu. yd. The illustrations on pages 671,.672 and 673 show the aqueduct in successive stages of construction. On page 672 the men are seen placing the concrete in forms with the aid of locomotive derricks and dumping buckets. Page 671 shows the concrete invert, steel inside and outside forms, placing arch concrete and completed concrete section.

Where hills or mountains cross the line, and it would be uneconomical to circumvent them, tunnels at the natural elevation of the aqueduct are driven through them. There are 24 of these grade tunnels, aggregating 14 miles. They also are horseshoe shape, 17 ft. high by 13 ft. 4 in. wide, and lined throughout with concrete.



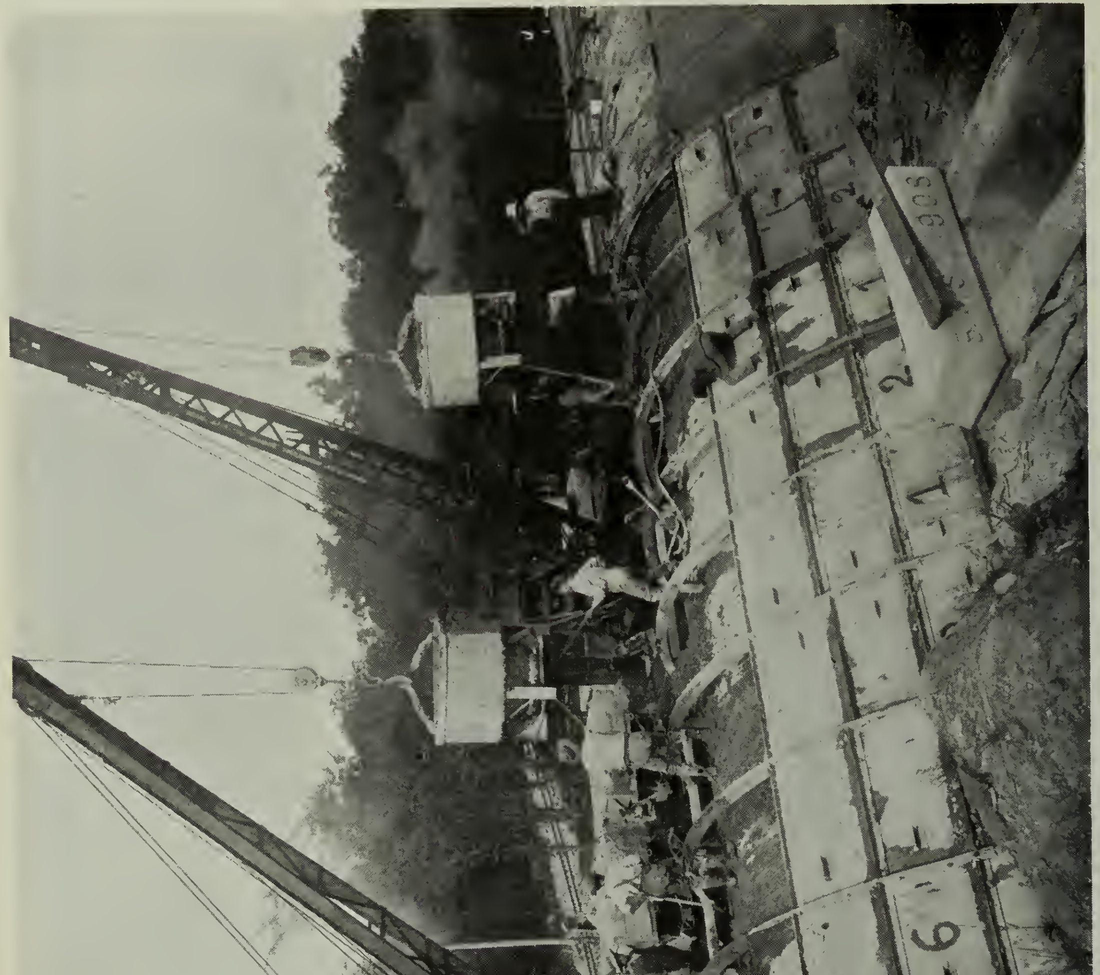
View showing Completed Concrete Section; Steel Forms; Placing Arch Concrete.
CUT AND COVER AQUEDUCT IN COURSE OF CONSTRUCTION.

Where deep and broad valleys must be crossed, and there is suitable rock beneath them, circular tunnels are driven at great depth in the rock and lined with concrete. There are 7 pressure tunnels, totalling 17 miles, with diameter of about 14 ft. A shaft at each extremity connects each pressure tunnel with the adjacent portions of the aqueduct.

Steel-pipe siphons are used in valleys where the rock is not sound, or where, for other reasons, pressure tunnels would be uneconomical. These steel pipes are made of plates rivetted together, from $\frac{7}{16}$ in. to $\frac{3}{4}$ in. in thickness, and are 9 ft. and 11 ft. in diameter. They will be lined with 2 in. of cement mortar, embedded in concrete, and covered with an earth embankment. There are 14 of these siphons, aggregating 6 miles.

THE OLIVE BRIDGE DAM.

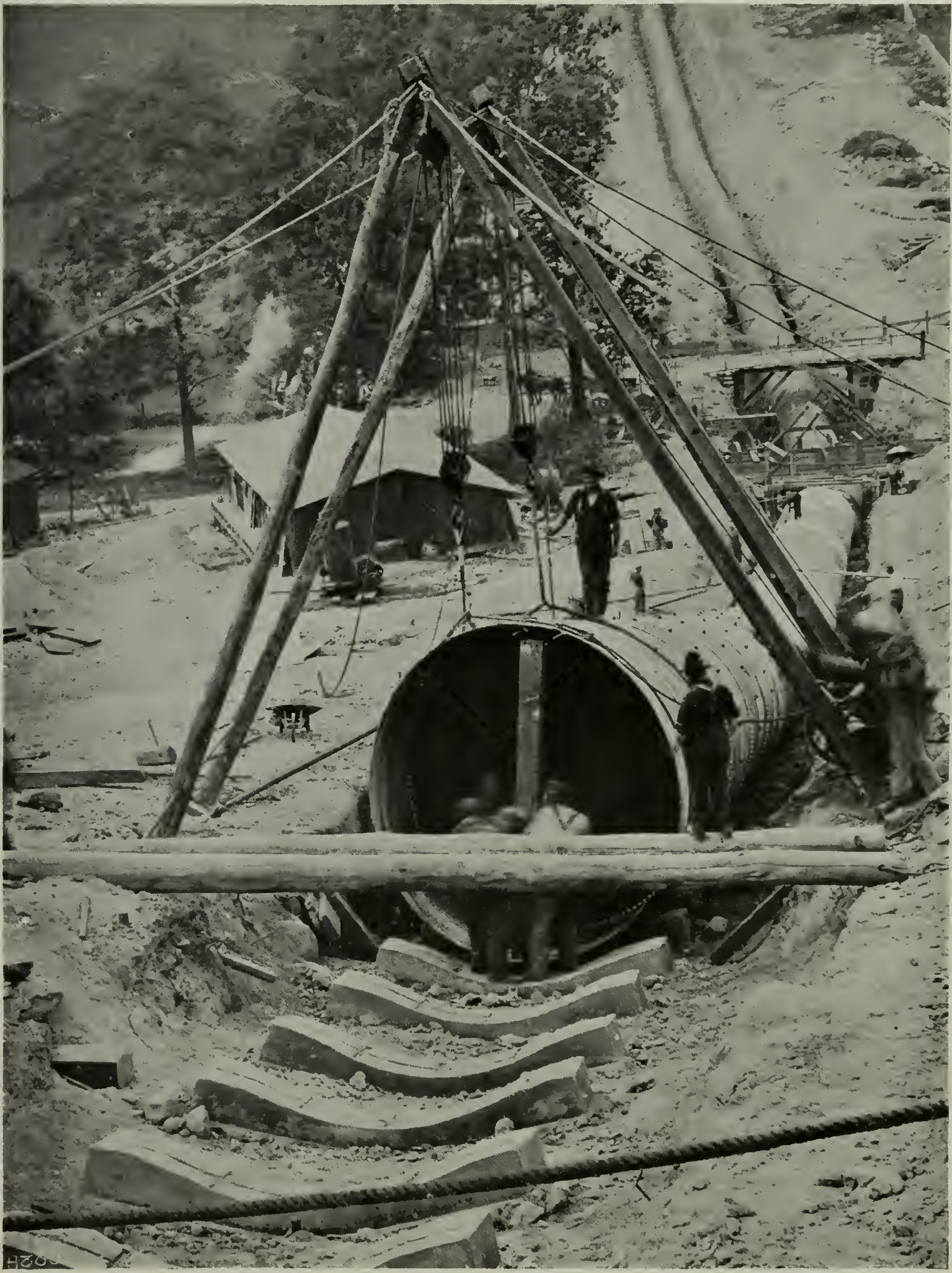
This dam and the Beaver Hill dykes form the Ashokan Reservoir. The reservoir will be 12 miles long and about 1 mile wide. The Olive Bridge Dam will be 1,000 ft long, rising to a height of 240 ft. The dam is faced up stream and down with concrete blocks enclosing a cyclopean fill. The blocks are made in wooden moulds having



Placing Concrete in Forms.
Cut and Cover Aqueduct in Course of Construction.

steel linings, which ensures a smooth surface in the finished block. The concrete is a 1 : 3 : 6 mixture.

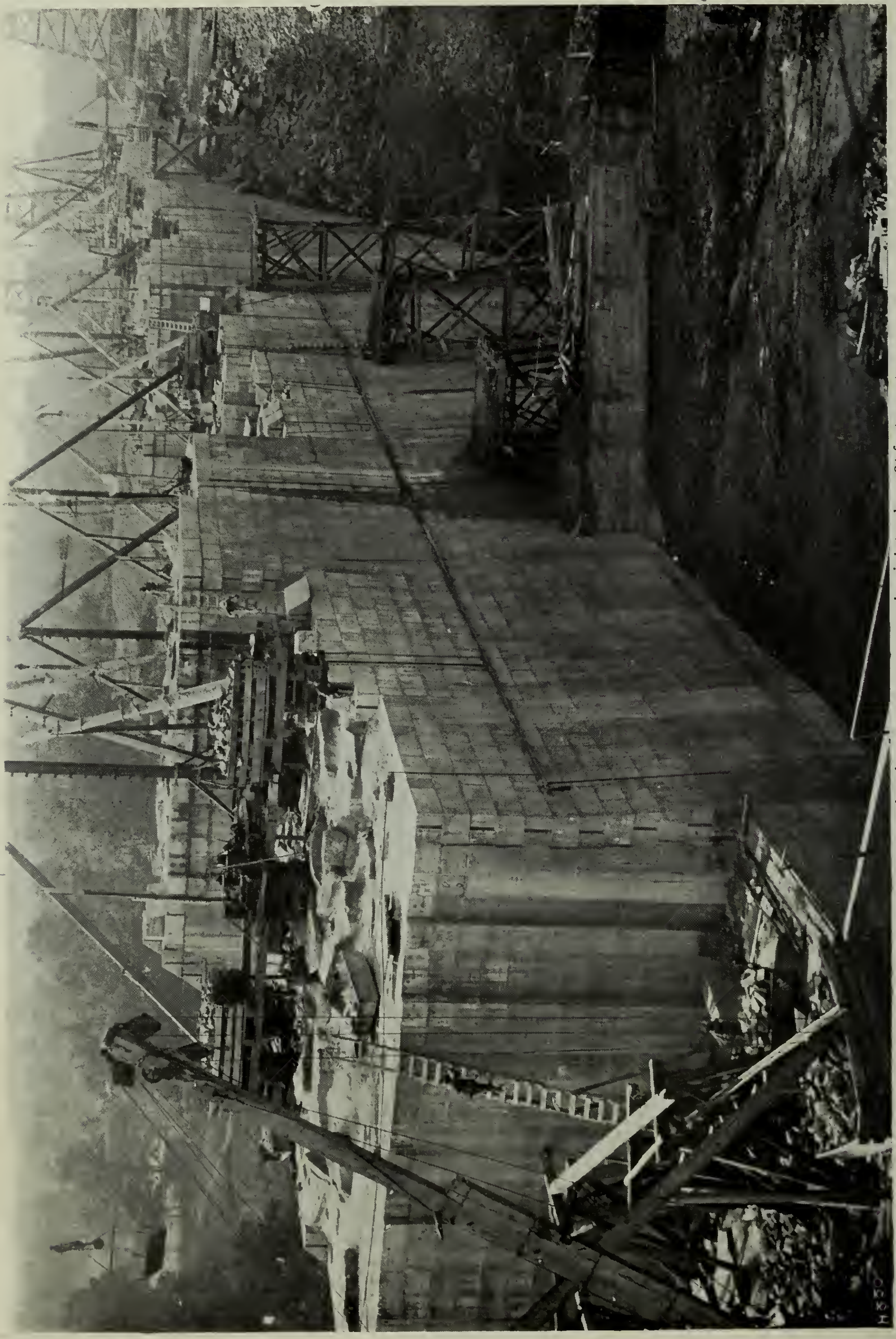
The total volume of concrete masonry in the dam will be 550,000 cu. yd., of which 65,000 cu. yd. will be formed of concrete blocks flanked by an earthen wing. Core walls of concrete will be built into these wings.



Steel Pipe Section, showing Method of Erection on Concrete Cradles.
Catskill Aqueduct.

The construction of the main dam for the Ashokan Reservoir is in the hands of Messrs. MacArthur Bros. Co. and Winston & Co.

The work is designed and supervised by the engineering bureau of the Board of Water Supply of New York, of which Mr. J. Waldo Smith is the chief engineer.



Concrete Section, showing transverse expansion joints about 84 feet apart.
Olive Bridge Dam.

THE ASSOCIATED PORTLAND CEMENT MANUFACTURERS (1900) LTD
HEAD OFFICE:- PORTLAND HOUSE, LLOYDS AVENUE, LONDON. E.C.
264
STAND No 26

PORTLAND CEMENT AT THE AGRICULTURAL SHOW, NORWICH.

The ever-growing uses of Portland cement in country work were admirably demonstrated at the Norwich Show, and similar exhibits should be arranged from time to time in different parts of the United Kingdom, so that the estate owner and farmer may learn the great economy and effectiveness of Portland cement for their everyday requirements.—ED.

At the Royal Agricultural Society's Show, held at Norwich recently, one of the most interesting stands was that of the Associated Portland Cement Manufacturers (1900), Ltd., where a new departure was made, inasmuch as none of their exhibits was for sale, but they were on view simply to show the many ways in which Portland cement can be utilised for agricultural purposes.

Amongst their exhibits were a rectangular cattle trough of 110 gallons capacity made of concrete reinforced with steel rods and wire netting, quite unbreakable, the cost of which was only 11s. 2d. ; a circular trough to hold 120 gallons, similarly reinforced, which cost 9s. ; a small hog trough and a chicken trough. Tiles for floors, walls, and roofing, both plain and coloured, were shown ; also the moulds and spare reinforcement for all the above-mentioned articles, so that everyone could see exactly how to make them.

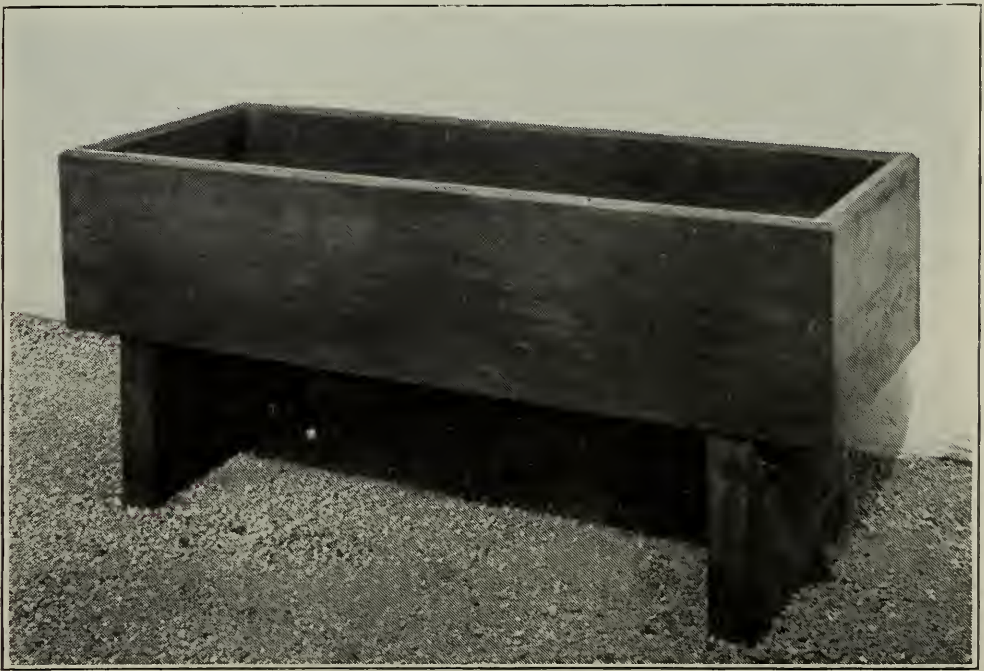


Fig. 1. Rectangular Cattle Trough.

One of the exhibits which appealed most to the majority of the large number of estate owners and agents who visited the stand was the reinforced concrete fence and gate posts, and the moulds in which they were produced, which could be made by any ordinary carpenter. It was pointed out that suitable aggregates can be obtained on almost every estate, and the low cost at which these posts can be made (fence post 1s. 9d., gate post 3s. 10d. each) should be a great inducement to estate people to replace wooden posts, which are a continual source of trouble, by concrete posts, as these latter increase in strength with age, and dampness, which destroys other materials, only tends to bring out the quality of the cement and make the concrete harder. They do not require painting or tarring, which is a matter of considerable saving, as no maintenance charges are incurred.

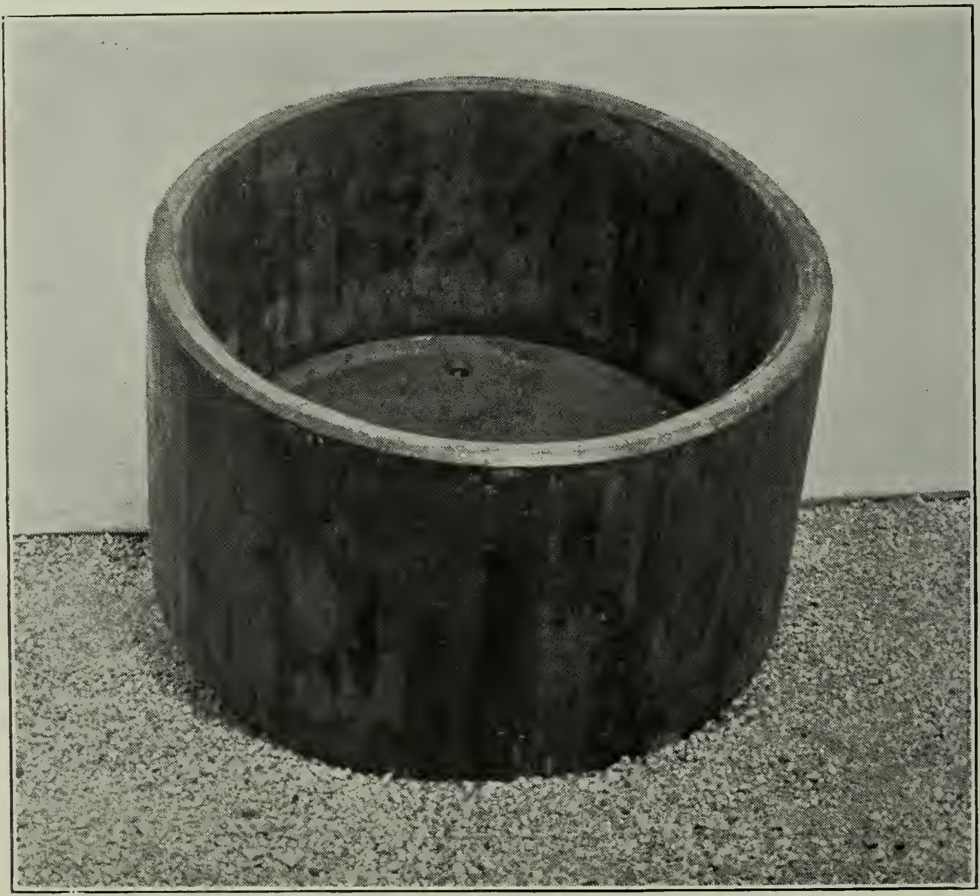


Fig. 2. Circular Tank.

Photographs were shown of half a mile of fencing erected on the Company's property, the cost of which, including posts spaced 12 ft. apart, straining posts, struts, plates for the feet of struts, five lines of 7-ply wire, with the requisite strainers, and the labour of erection, was only 1s. 2d. per yard run, which compares very favourably in first cost with wooden posts, and the cost of maintenance is practically nil.

One end of the stand was enclosed with reinforced concrete rail fencing, which is eminently suited for cattle pens, stud paddocks, etc., as there is no possibility of cattle breaking it down, and it meets the requirements of the Board of Agriculture in regard to cleanliness.

Another application of concrete to agricultural work is for rick stands, and one is shown in *Fig.* 5. The pillars of this stand are formed of concrete, being 4 ft. high, $18\frac{1}{2}$ in. square at the base, and 8 in. square at the top. The pillars shown were made exceptionally long, as the district in which the rick was situated was subject to floods.

They also showed a hydraulic crushing machine for testing the crushing strain of concrete cubes, some composed of cement of their own manufacture and three parts of sand, standing 7,000 lb. per sq. in. These machines, which are made at their engineering works, are compact and reliable. The dial on the pressure gauge shows pounds per square inch, kilos. per square centimetre, tons per square foot, and total tons on the block. The selling price is £50.

" Poilite," a light roofing tile manufactured by Bells Asbestos Co., which consists mainly of Portland cement, attracted a good deal of attention, as did a small machine for making concrete drain pipes, which have the advantage over clay pipes that they are perfectly true, showing no sign of warping, cost less, and do not deteriorate with age.

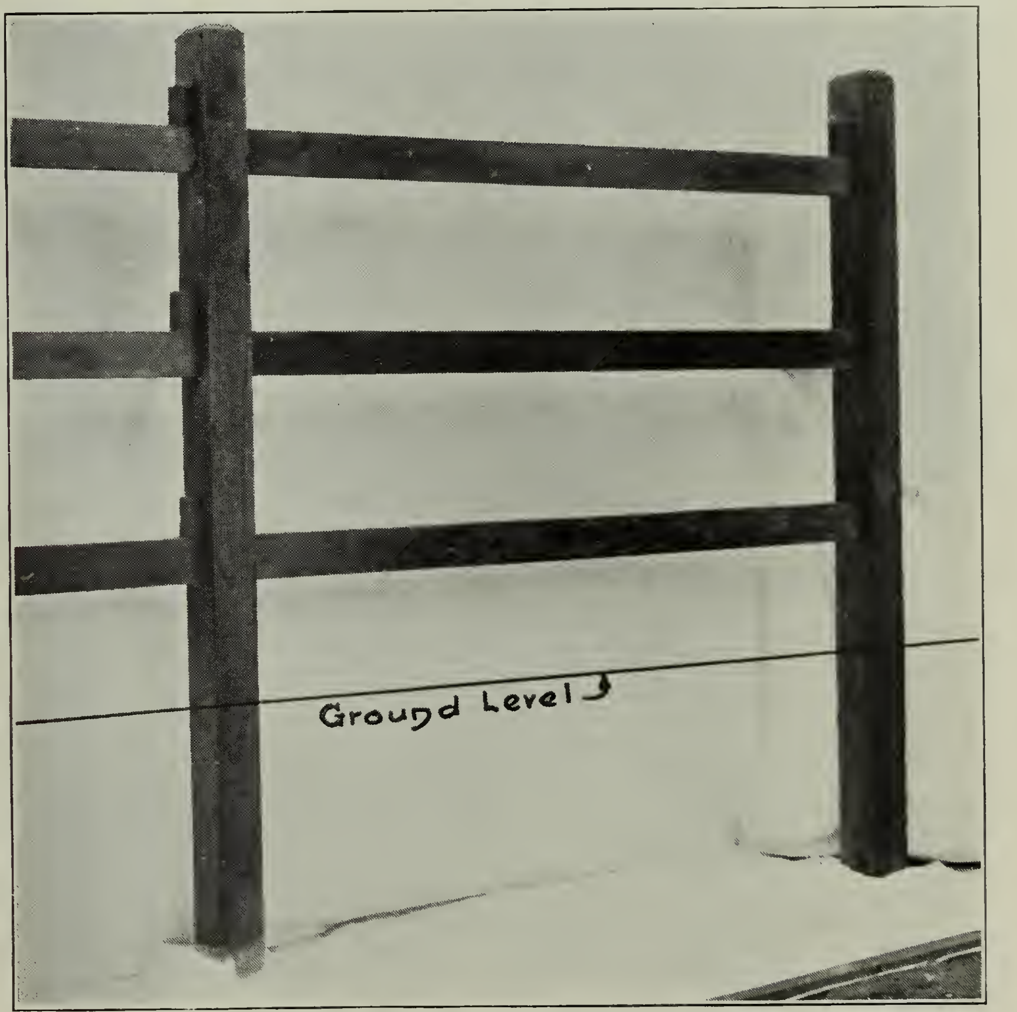


FIG. 3. RAIL FENCE.

Two hand-power machines made by the Winget Concrete Machine Co. were being worked on the stand. One, known as the " Winget," makes hollow or solid blocks for the erection of buildings up to a maximum size of 32 in. by 16 in. by 9 in. This machine makes every size and description of block necessary for the erection of neat and substantial dwellings, farm buildings, silos, etc., including partition walls, chimney and flue blocks, etc. The other machine is a smaller type than the " Winget," and is known as the " Titan." This machine produces blocks of the maximum size of 16 in. by 9 in. by 9 in. hollow or solid.

Each machine is provided with the necessary attachments to make the face of the block either "Rock" pattern or any one of seven different designs, so that a building may have its walls of either plain flat blocks or have the faces diversified in a manner agreeable to the owner.

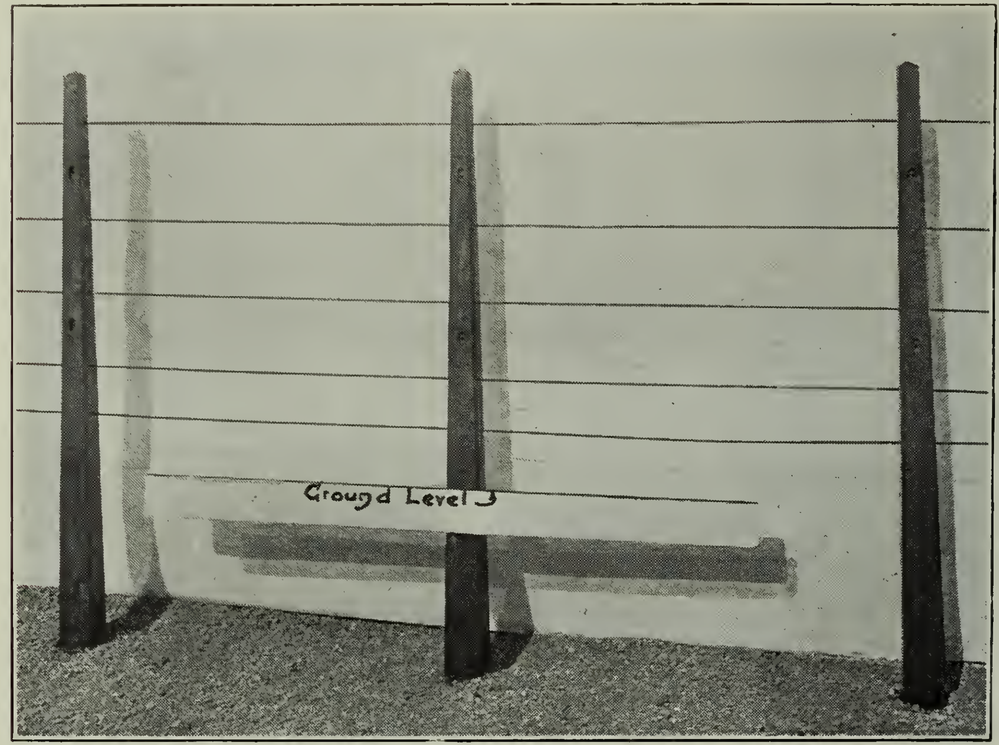


Fig. 4. Posts for Wire Fencing.

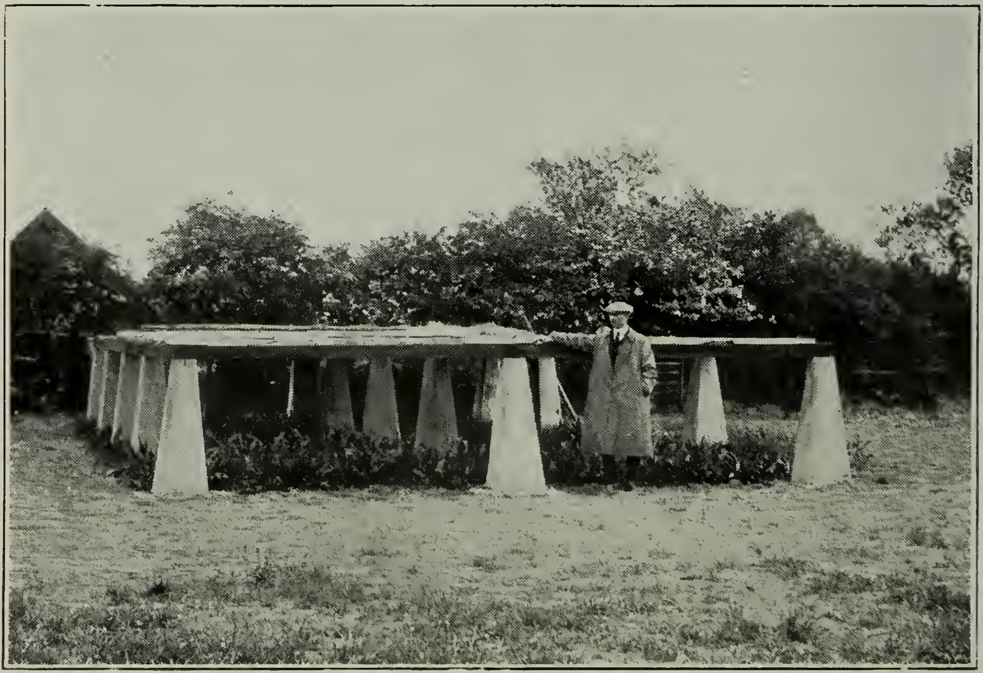


Fig. 5. Rick Stand.

It was a revelation to see a couple of unskilled labourers ramming concrete into the "Winget" machine, and when this operation was completed a single pull at a lever revealed what appeared to be a beautifully finished and worked stone which would be a credit to any mason or builder.

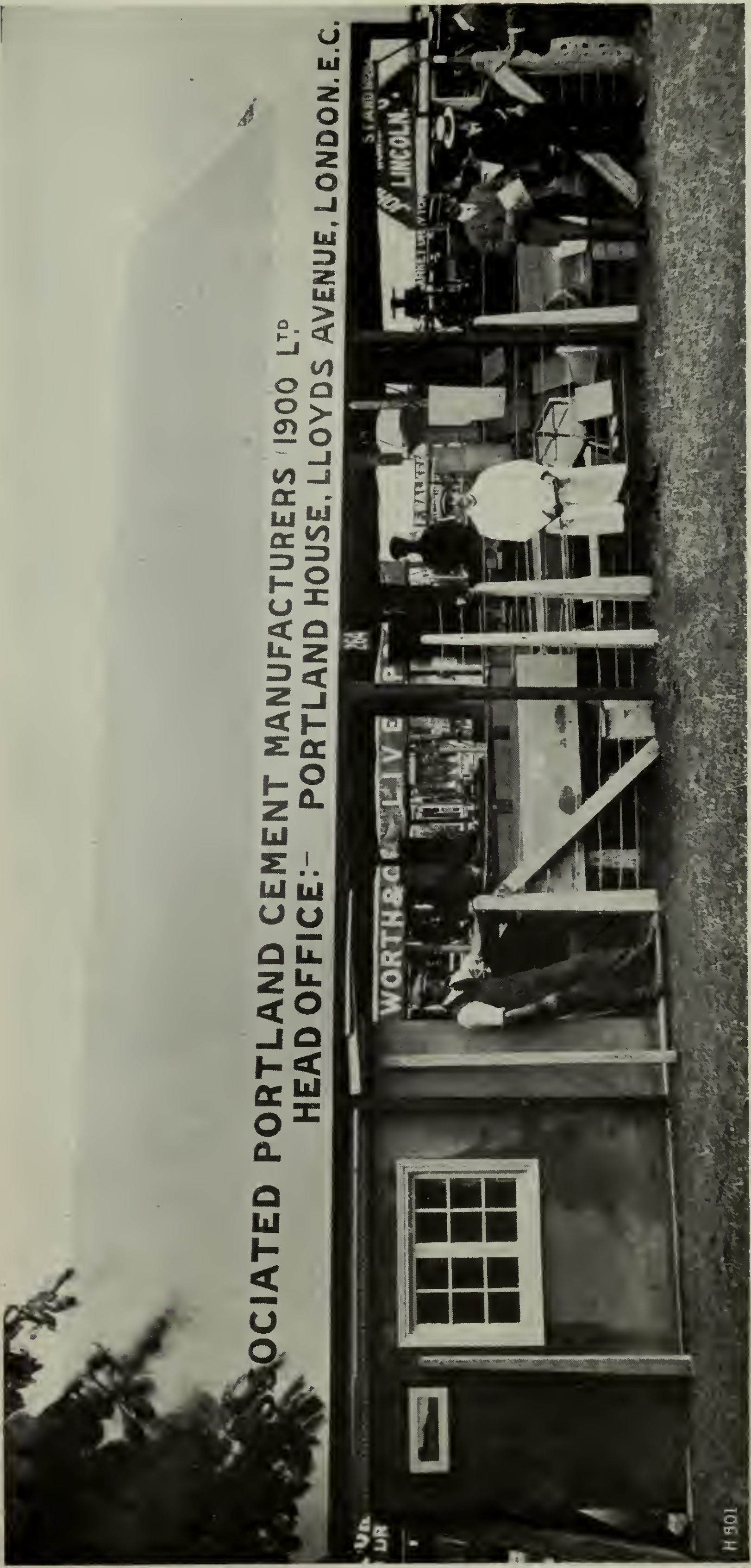

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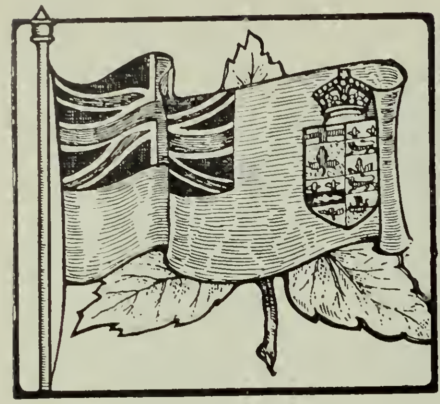
Fig. 6. The Associated Portland Cement Manufacturers' Stand at Norwich.

In actual operation 450 of these stones, 32 in. by 9 in. by 9 in., have been produced on the "Winget" in a working day of 10 hours (the makers guarantee 200).

The "Titan," with a man and a boy, will produce about 100 16 in. by 9 in. by 9 in. blocks in a working day.

With special attachments the "Winget" also makes 2½ in. to 4 in. partition slabs, kerb, coping, water tabling, garden edging, etc.; in fact, with this machine almost every stone required in the construction of a building whose size is within the capacity of the machinery can be made.

Particulars of the exhibits and instructions how to make most of the articles which were on view are embodied in a pamphlet entitled "Concrete and Its Uses on the Farm," and this will be sent on application to the Associated Portland Cement Manufacturers (1900), Ltd., Portland House, Lloyds Avenue, London, E.C.



CANADIAN STANDARD BUILDING REGULATIONS FOR REINFORCED CONCRETE.

At the Annual Meeting of the Canadian Cement and Concrete Association, held in Toronto recently, the following building regulations for reinforced concrete work were adopted by the Association.—ED.

I. GENERAL.

1. There shall be no fixed limit to the height of buildings of reinforced concrete except that arising from the requirements of these regulations.

2. Before permission is granted by the Building Department to erect any reinforced concrete building, complete plans, accompanied by specifications, signed by the engineer and architect, must be filed with the Building Department and remain on file for public inspection until the building is completed.

3. The Building Department shall have access to the computations. These shall give the various loads assumed, such as dead, live, and wind loads, the impact allowance, if any, and the resulting maximum stresses.

4. The specifications shall state the qualities of the materials to be used for making the concrete and the density and strength required.

5. Upon the completion of the building the engineer and architect shall issue, under the approval of the Building Department, signed certificates, to be posted on each floor of the building, stating the safe carrying capacity per sq. ft.

6. There shall be kept, for the inspection of the Building Department, careful records of the progress of the work. These records shall show the date of placing of all the concrete, the date of removal of the forms, and they must be turned over to the Building Department when the building is completed.

7. Reinforced concrete walls may be used in place of brick or stone exterior or bearing walls with thickness reduced to two-thirds the thickness specified for brick walls. Such walls shall not be less than four (4) inches thick.

8. Reinforced concrete walls shall be reinforced at both faces. The maximum spacing of bars in the same vertical plane shall be 18 in. on centres. The quantity of metal employed shall be sufficient to provide for a uniformly distributed horizontal pressure of 30 lb. per sq. ft. acting on either side of the wall.

II. MATERIALS.

9. Only Portland cement shall be used in reinforced concrete structures which meets the requirements of the specifications of the Canadian Society of Civil Engineers.

10. Tests of the cement used in building operations shall be made from time to time under the supervision of the Building Department and in accordance with the preceding specifications.

11. Fine aggregates shall consist of sand, crushed stone, or gravel screenings graded from fine to coarse and passing, when dry, a screen of $\frac{1}{4}$ in. mesh. Not more

than 6 per cent. shall pass a screen having 100 meshes to the lineal inch. They shall be of clean, silicious material, free from vegetable loam or other deleterious matter.

12. Mortars composed of 1 part Portland cement and 3 parts fine aggregate, when made into briquettes, shall show a tensile strength at least equal to the strength of 1 : 3 mortar of the same consistency and age made with the same cement and standard Ottawa sand.

13. Coarse aggregates shall consist of inert material graded in size, such as crushed stone or gravel, which is retained on a screen of ¼-in. mesh. The particles shall be clean, hard, durable, and free from all deleterious material. The maximum size of the coarse aggregates shall be such that they will not separate from the mortar in laying, and will flow readily around the reinforcement and into all parts of the forms.

14. Cinder concrete shall not be used for reinforced concrete structures ; it may be used for fireproofing. Where cinders are used as the coarse aggregate, they shall be composed of hard, clean, vitreous clinker, free from sulphides, unburned coal, or ashes.

15. Medium steel for reinforcement shall have an ultimate tensile strength of 58,000 to 66,000 lb. per sq. in., an elastic limit of not less than one-half the ultimate strength and a minimum percentage elongation in 8 in. of 1,500,000 divided by the ultimate strength. In all respects not covered by this specification, medium steel shall conform to the requirements of the General Specifications for Steel Bridges and Viaducts of the Department of Railways and Canals, Canada, 1908.

16. High elastic limit steel for reinforcement shall be made entirely from new billets, and shall have an ultimate tensile strength of 80,000 to 96,000 lb. per sq. in., an elastic limit of at least half the ultimate strength, and a minimum elongation in 8 in. of 1,200,000 divided by the ultimate strength. It shall bend cold 180 degrees around a pin the diameter of which is four times the thickness of the bar without showing fracture on the outside of the bend.

17. All loose rust, scale, or dirt shall be removed from reinforcement steel before it is placed in the work.

III. DESIGN.

1. GENERAL ASSUMPTIONS.

18. The ratio between the moduli of elasticity of steel and concrete shall, for a concrete crushing at 2,000 lb. per sq. in. in 28 days, be assumed as 15.

19. The compressive stresses in a reinforced concrete beam shall be assumed to vary directly as the distance from the neutral axis.

20. The tensile resistance of concrete shall be assumed to be zero.

21. Where adequate bond between slab and web of beam is provided, the slab may be considered as an integral part of the beam, and its effective width may be determined by the following rules :

(*a*) It shall not exceed one-fourth of the span length of the beam.

(*b*) Its overhanging width on either side of the web shall not exceed four times the thickness of the slab, nor twice the thickness of the web.

(*c*) Where the slab extends on only one side of the beam, it shall be permissible to consider as effective flange area an overhanging width not greater than four times the thickness of the slab or twice the thickness of the web.

2. BENDING MOMENTS.

22. In computing the positive and negative moment in beams and slabs continuous over several supports, due to uniformly distributed loads, the following rules are recommended :

(*a*) That for floor slabs the bending moments at centre and at support be taken at $\frac{w l^2}{12}$ for both dead and live loads, where w represents the load per lineal unit and l the span length.

(*b*) That for beams the bending moment at centre and at support for interior spans be taken at $\frac{w l^2}{12}$ and for end spans be taken at $\frac{w l^2}{10}$ for centre and adjoining support, for both dead and live loads.

23. Floor slabs shall be designed and reinforced as continuous over the supports. The distribution of loads longitudinally and transversely in slabs reinforced in both directions shall be determined by the following formula :

$$r = L^4 \div (L^4 + B^4)$$

where r is the ratio of the load carried transversely to the whole load, L is the length and B the breadth of the slab. If the length of the slab exceeds 1·5 times its width, the entire load shall be assumed to be carried by the transverse reinforcement. Square slabs are preferably reinforced in both directions, using reinforcement in each direction calculated for one-half the specified load.

24. The loads carried to beams by slabs which are reinforced in two directions will not be uniformly distributed to the supporting beams, but may be assumed to vary as the ordinates on the sides of an isosceles triangle, the base of which is the length of the beam. The moments in the beams should be calculated accordingly.

3. Working Stresses.

25. The working stresses proposed below are for a concrete, the ultimate crushing strength of which at an age of 28 days is 2,000 lb. per sq. in. For concrete of greater or less compressive strength, proportionate increments to, or reductions from, the proposed stresses shall be made.

(*a*) The maximum allowable compressive stress on the extreme fibre of beams shall be 650 lb. per sq. in.

(*b*) The maximum allowable compressive stress on concrete in columns without hoops or in columns reinforced with less than 1 per cent. of hooping, shall be 500 lb. per sq. in.

(*c*) Pure shearing stresses, uncombined with tension or compression, shall not exceed 120 lb. per sq. in.

(*d*) Shearing stress, combined with diagonal tension, shall not be greater than 40 lb. per sq. in.

(*e*) The maximum allowable bond stress between concrete and plain steel shall be 60 lb. per sq. in., and between concrete and deformed bars approved by the architect or engineer, 120 lb. per sq. in.

(*f*) The tensile stress on steel reinforcement shall not exceed one-half of the elastic limit of the steel nor in any case 16,000 lb. per sq. in.

(*g*) Columns reinforced with longitudinal reinforcement only shall be figured for a working stress in the concrete of 500 lb. per sq. in., and in the steel, a stress of 7,500 lb. per sq. in.

(*h*) Columns with at least 1 per cent. of reinforcement in the form of bands or hoops shall be figured at a working stress of 500 lb. per sq. in. on the concrete.

(*i*) Columns reinforced with at least 1 per cent. and not more than 4 per cent. of longitudinal bars, and with at least 1 per cent. of reinforcement in the form of bands or hoops, or with structural steel column units which thoroughly encase the concrete core, shall be figured at working stresses of 650 lb. per sq. in. on the concrete, and 9,750 lb. per sq. in. on the longitudinal reinforcement.

4. Details of Design.

26. The lateral spacing of bars should not be less than three diameters, centre to centre, nor should the distance from the side of the beam to the centre of the nearest

bar be less than two diameters. The clear spacing between two layers of bars should be not less than 1 in. In no case shall the minimum thickness of fireproofing be less than that specified by the Building Department.

27. In the calculation of web reinforcement to provide a strength of 120 lb. per sq. in., which is assumed to be the maximum permissible vertical shearing stress on beams, no matter how well reinforced for diagonal tension, the concrete may be counted upon as carrying one-third of the shear, or for 2,000 lb., concrete, 40 lb. per sq. in. The remainder may be provided for by means of metal reinforcement, consisting of bent bars or stirrups, but preferably both. The area of a stirrup, acting in tension, must be proportioned to the force equal to the whole horizontal shear produced between the two adjacent stirrups less the amount to be carried by the concrete. This total horizontal shear may be found by multiplying the distance between the stirrups by the average horizontal unit shear, which is equal to the vertical unit shear, and is represented by the expression $\frac{V}{d}$, where V is the total vertical shear not carried by the concrete, and d is the depth of the beam to the centre of the steel. In accordance with this method, the stress in a vertical stirrup will be equal to $\frac{Vs}{d}$ and in a stirrup or rod bent at 45 degrees it will be $0{\cdot}7\,\frac{Vs}{d}$, in which s is the horizontal spacing of stirrups or bent rods in the direction of the axis of the beam.

28. The longitudinal spacing of stirrups shall be such that at least one rod shall intersect below the centre of the beam any 45 degree line of rupture in the portion of the beam where the shearing stresses exceed the allowable shearing value of the concrete.

29. The ratio of unsupported length of columns to their least width shall be limited to 15.

30. The effective area of the hooped column shall be taken to be the area within the protective covering which shall not be less than 2 in. in thickness. In the case of columns reinforced with structural shapes, it shall be taken as the area wholly within the structural shapes.

31. Bars composing longitudinal reinforcement must be straight, and shall have sufficient lateral support to hold them securely in place until the concrete is placed.

32. The clear spacing of bands or hoops shall not be greater than one-eighth the diameter of the enclosed column. Adequate means must be provided to hold bands or hoops in place so as to form a column, the core of which shall be straight and well centred.

33. Bending stresses due to eccentric loads must be provided for by increasing the section until the maximum stress does not exceed the values specified above.

34. At the bases of columns, longitudinal reinforcement shall abut squarely on bearing plates, or shall be carried into the footing a sufficient distance to develop the compressive stress in the reinforcement on the basis of the working stresses specified above.

35. In columns, all longitudinal reinforcing rods shall be properly butted or spliced.

36. Wherever it is necessary to splice reinforcement by means of lapping, the length of the lap shall be determined upon the basis of the safe bond stress, and the stress in the bar at the point of splice ; or, a connection shall be made between the bars of sufficient strength to carry the stress. Splices at the point of maximum stress must be avoided.

37. Where large areas of concrete are exposed to atmospheric conditions, the changes of form due to shrinkage and variation of temperature must be provided for by placing small rods or light fabric near the exposed surface, of a quantity to be determined on the basis of the elastic and thermal properties of the materials.

IV. CONSTRUCTION.

38. The ingredients of concrete shall be thoroughly mixed to the desired consistency and the mixing shall continue until the cement is uniformly distributed and the mass is homogeneous and uniform in colour.

39. Methods of measuring and proportioning the ingredients shall be such as are approved by the engineer or architect.

40. When the conditions will permit, a machine mixer of a type which ensures the uniform distribution of the materials throughout the mass shall be used.

41. When it is necessary to mix by hand, the mixing shall be on a watertight platform, and special precautions must be taken to turn the materials until they are homogeneous in appearance and colour.

42. The materials must be mixed wet enough to produce a concrete of such consistency as will flow readily into the forms and about the reinforcement, and which, on the other hand, can be conveyed from the mixer to the forms without separation of the coarse aggregate from the mortar.

43. Retempering mortar or concrete—*i.e.*, remixing with water after it has partially set—shall not be permitted.

44. Concrete shall be rapidly and continuously handled from the time the water is added until it is finally placed in the work. The placing shall be facilitated by the use of suitable agitating and ramming tools, so as to produce a thoroughly compact concrete of maximum density.

45. Concrete exposed to premature drying shall be kept damp for a period of at least four days.

46. Before concrete is placed, care shall be taken to see that the forms are substantial and thoroughly wetted, and that the space is entirely free from debris.

47. When work is resumed, concrete previously placed shall be roughened, thoroughly cleaned of foreign material and laitance, drenched and slushed with a mortar consisting of 1 part Portland cement, and not more than 2 parts fine aggregate.

48. Where concrete must be placed under water, unusual care must be taken to prevent the cement from being washed away.

49. Concrete shall not be mixed or deposited at a temperature lower than 28 degrees Fahr. unless special precautions are taken to avoid the use of materials containing frost or covered with ice crystals, and to provide means to prevent the concrete from freezing after being placed in position.

50. The reinforcement shall be accurately located in the forms as required by the plans and carefully secured by wiring or other means against displacement before placing the concrete.

51. Reinforced concrete work shall be stopped at points where joints will have the least possible effect on the strength of the structure.

(*a*) Footings shall, where practicable, be cast to their full depth at one operation.

(*b*) Columns shall be cast at a single operation and work shall be stopped at the underside of the lowest beams or girders bearing on the columns. Where a bracket is used, the bracket shall be considered a part of the beam or girder.

(*c*) Construction joints in beams and girders shall be vertical and at the centre of the span. Any concrete which may run past the bulkheads must be cleaned up before the concreting of the next section is started.

(*d*) Construction joints in slabs shall be at the centre of the span. Where a joint occurs between a slab and a beam or girder, no T-action in figuring the beam or girder shall be considered.

52. No forms shall be removed without the written consent of the engineer or architect.

53. Wherever floors are built with a combination of tile or other fillers between joints, the following rules regarding the dimensions and methods of calculation shall be observed.

(*a*) The ratio of minimum depth to clear span of joist shall not be less than 1 to 24.

(*b*) Wherever a portion of the slab above the tile joist shall be considered as acting as a T-beam section, the slab portions must be cast monolithic with the joist, and must have a minimum thickness of 2 in. In such a case all regulations applying to T-beams shall apply to tile and joist construction.

(*c*) In no case shall the tile or other fillers be considered as bearing stress.

(*d*) Wherever porous tiles, or other materials which by their nature will absorb water from the concrete, are used between the joists, care must be taken to thoroughly saturate the tiles, or other materials, with water immediately before the concrete is placed.

AN IMPROVED SYSTEM OF REINFORCED CONCRETE CONSTRUCTION.

The following particulars of a new system of design claim attention for, although naturally ex parte as emanating from the proprietors, their practical experience and high standing in the industry give their arguments weight.—ED.

THE "KEEDON" SYSTEM.

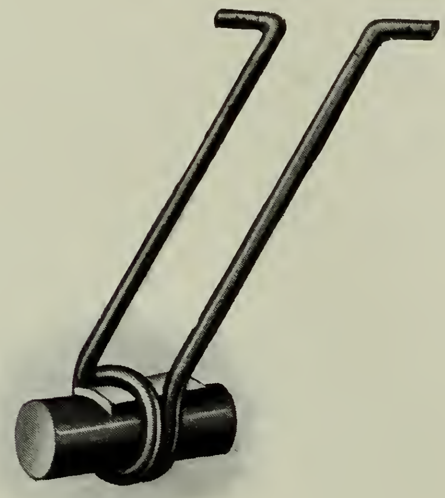


Fig. 1.

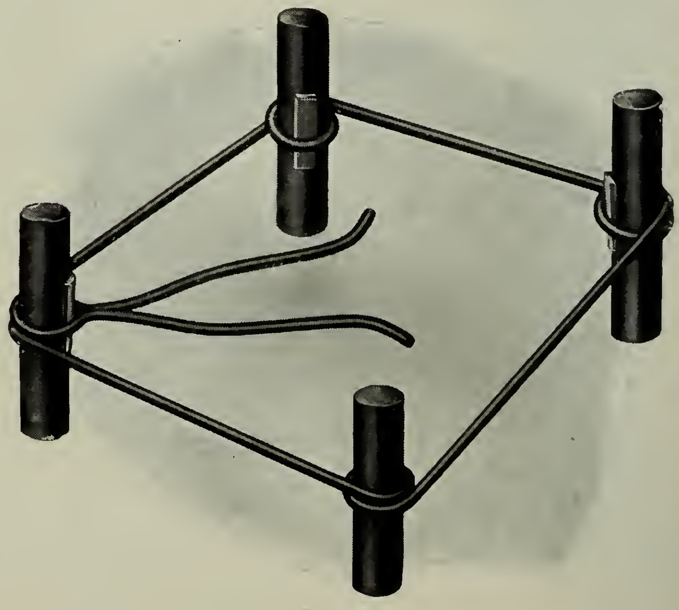


Fig. 2.

Tests have definitely established the value of a rigid attachment of shear members to the main bars in the reinforcement of concrete beams. The R.I.B.A. Joint Committee on Reinforced Concrete urge that stirrups should be anchored at both their ends. In the "Keedon" system of Messrs. Richard Johnson, Clapham & Morris, Ltd., this desideratum is effected as shown in *Fig.* 1—namely, by looping the stirrup round the bar and fixing it in position with a wedge. Theory also shows the economy of metal in the stirrups by inclining them at 45° to the horizontal, and this disposition can be easily secured, as shown by the "Keedon" method, though if desired they can be placed in an upright position. Besides increased resistance there are other points wherein such a system increases efficiency. It is very important that all reinforcements should be in their exact place, and to secure this close inspection before putting in the concrete is necessary, but the labour of inspection is reduced, and greater exactitude obtained, when the whole of the steel reinforcement can be assembled together without risk of displacement afterwards in the interval between inspection and execution. Moreover, if the secondary members are rigidly fixed so that they cannot easily get displaced in the process of tamping and ramming the concrete, the efficiency of the structure is still further improved. It is also important that these secondary reinforcements should bind tightly so that they can immediately take stress under loading, and this is secured by such a rigid attachment. For these several reasons there are advantages in applying a similar method of attachment to the reinforcement of columns, struts, piles, etc., as shown in *Fig.* 2. The method of attachment also permits of the reinforcement for beams and columns, etc., being

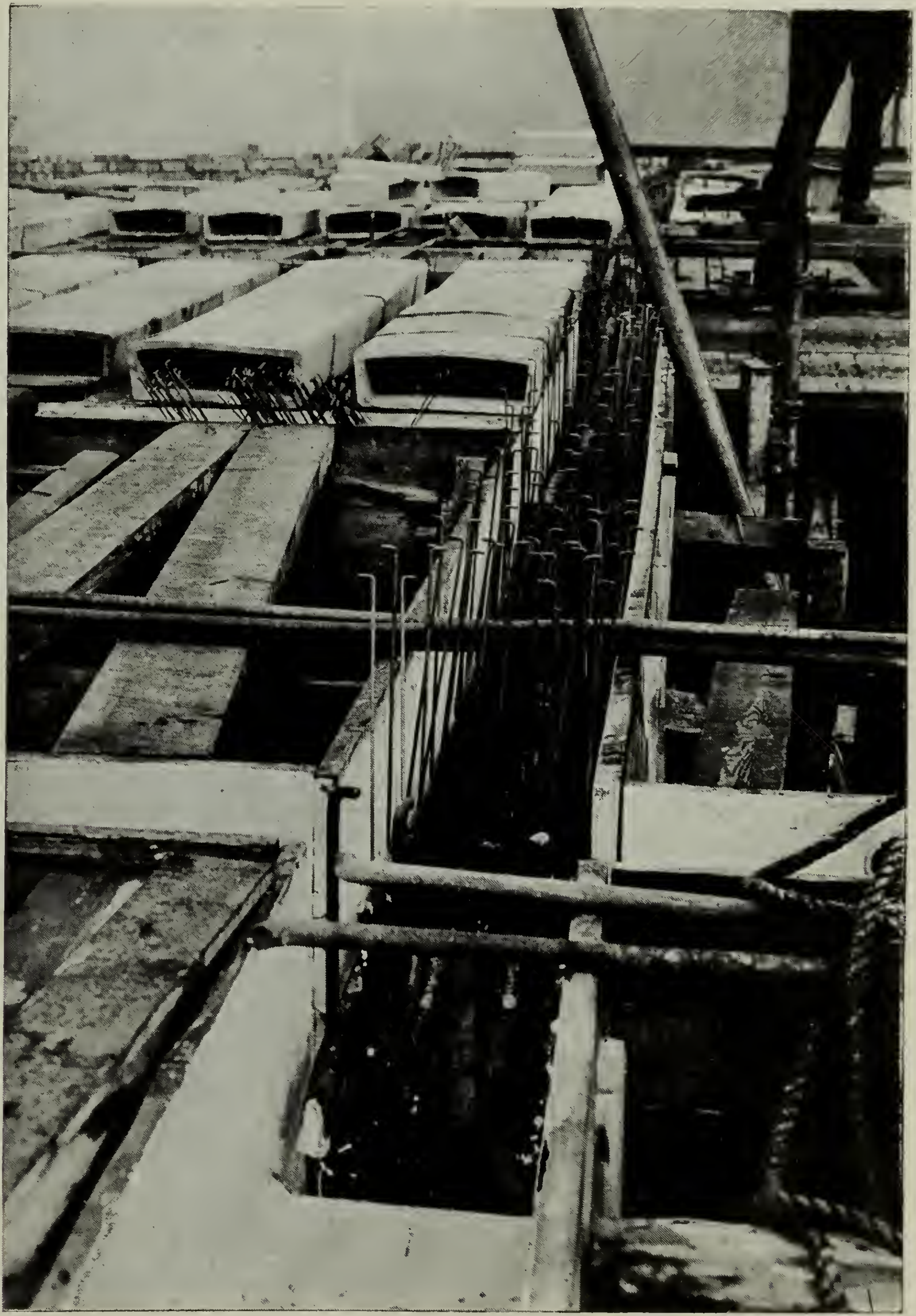
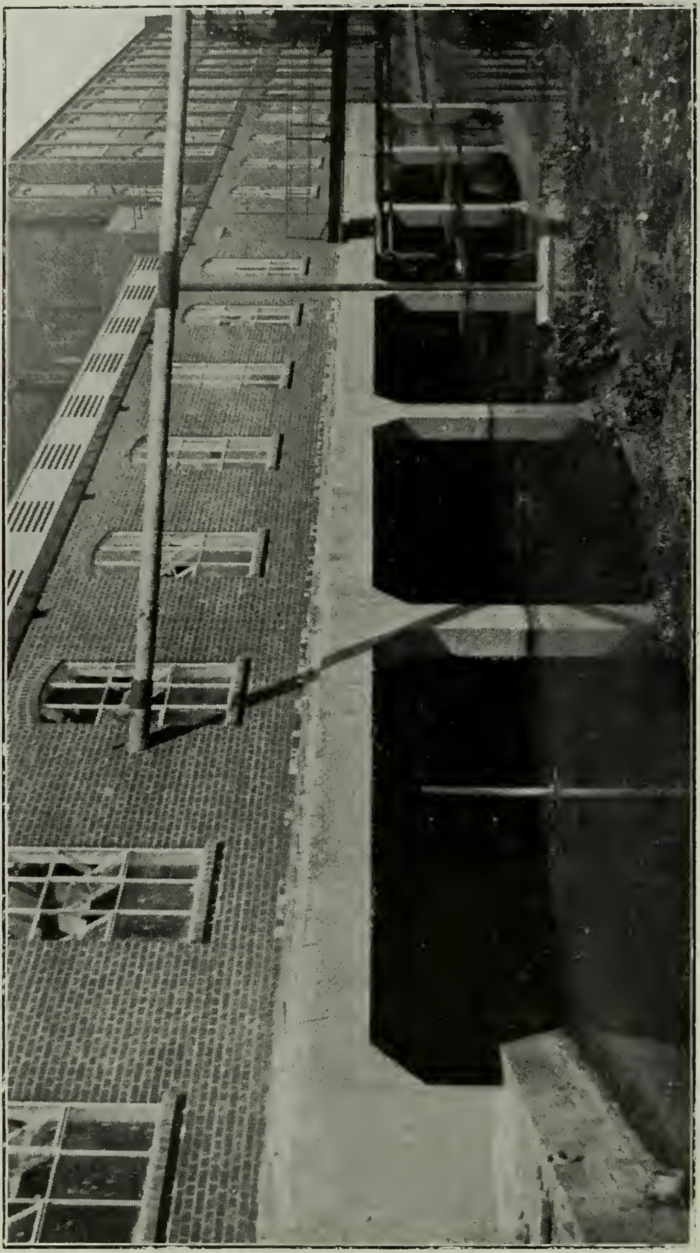


Fig. 3. View Showing "Keedon" Reinforcement in Place.
Building in Course of Construction for the Manchester Ship Canal Company.

assembled as units ready to be placed, as a whole, in the boxes, and so facilitates building operations.

We may also point out that in placing bars one over the other in beams they should be separated by a slight distance, so as to allow the concrete to get between and adequately protect the steel, and this is secured in this system by the wedges and loops standing up sufficiently to allow a second bar to rest the right distance above.

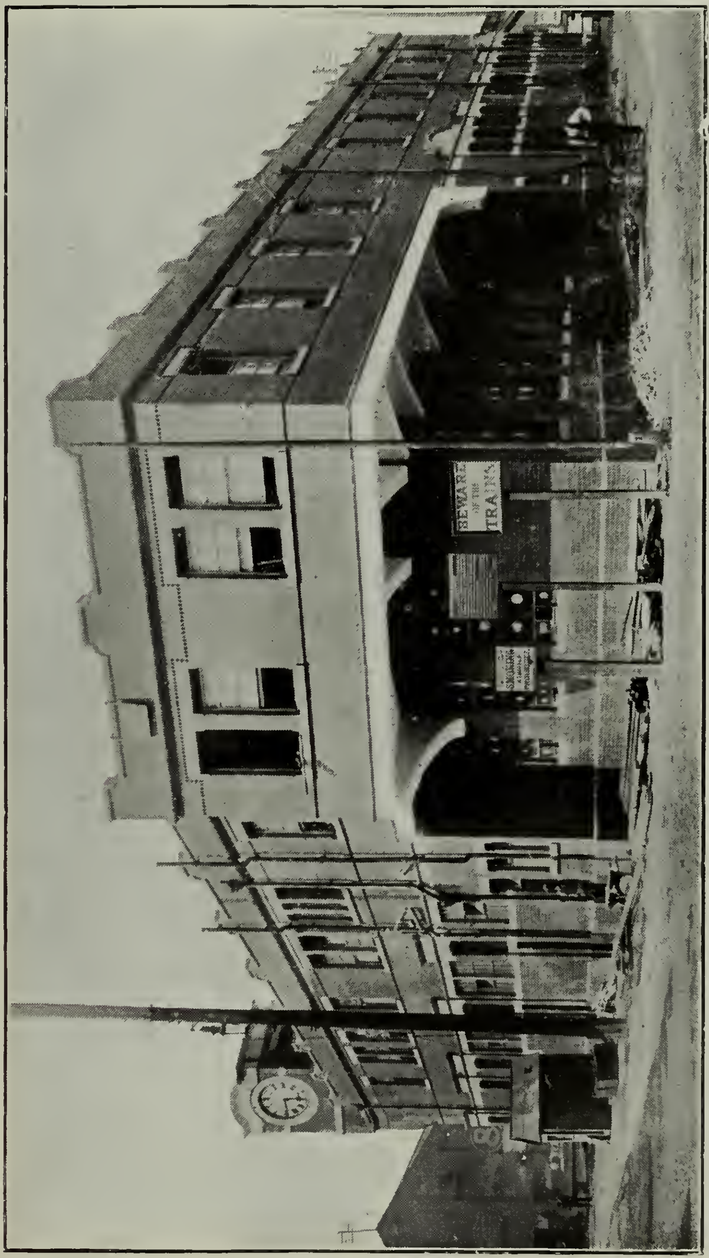


Reinforced entirely on "Keedon" System.

Extension to Dye-house for Messrs. Courtaulds, Braintree.

The "Keedon" connection is quickly made, the stirrups or binders and keys being made interchangeable. It is obvious that the secondary reinforcements can be spaced any distance apart and made of any length, as required to resist the imposed stresses, and therefore more latitude is given than with any arbitrary system. The "Keedon" stirrups are not likely to slide along the main bars in beams, because the more they are stressed the harder do they bind by reason of the loop and key connection.

The makers point out that the main reinforcements are formed of ordinary merchantable steel bars, and that the "Keedon" links and keys can be purchased by anyone in the trade with or without the main bars, and that the "Keedon" reinforcement is sold at a fixed price, no charge being made for drawings, fees, etc.



Reinforced on "Keedon" System.
New Labour Booking Office, Manchester Ship Canal Co.

The links are made of drawn steel wire, which is, of course, stronger than ordinary rolled steel. The "Keedon" reinforcements lend themselves to close packing and easy handling since they are made in separate units.

Fig. 3 shows the system in application in practical work, the illustration showing the reinforcement of a heavy main beam with stirrups all in place ready for filling in the concrete.

TESTS ON CONCRETE BEAMS.

In order to demonstrate the advantages of having fixed inclined "Keedon" stirrups, tests were carried out by the Manchester School of Technology, and we give a copy of their report herewith. The beams were designed according to the R.I.B.A. formulæ, and were estimated to carry an ultimate load of 40 tons distributed over the span. The stirrups were calculated to carry the maximum shear, and spaced accordingly, both beams being spaced alike.

MANCHESTER TECHNICAL SCHOOL.

Report of Cross-breaking Tests of Two Reinforced Concrete Beams.

Built for Messrs. R. Johnson, Clapham & Morris.

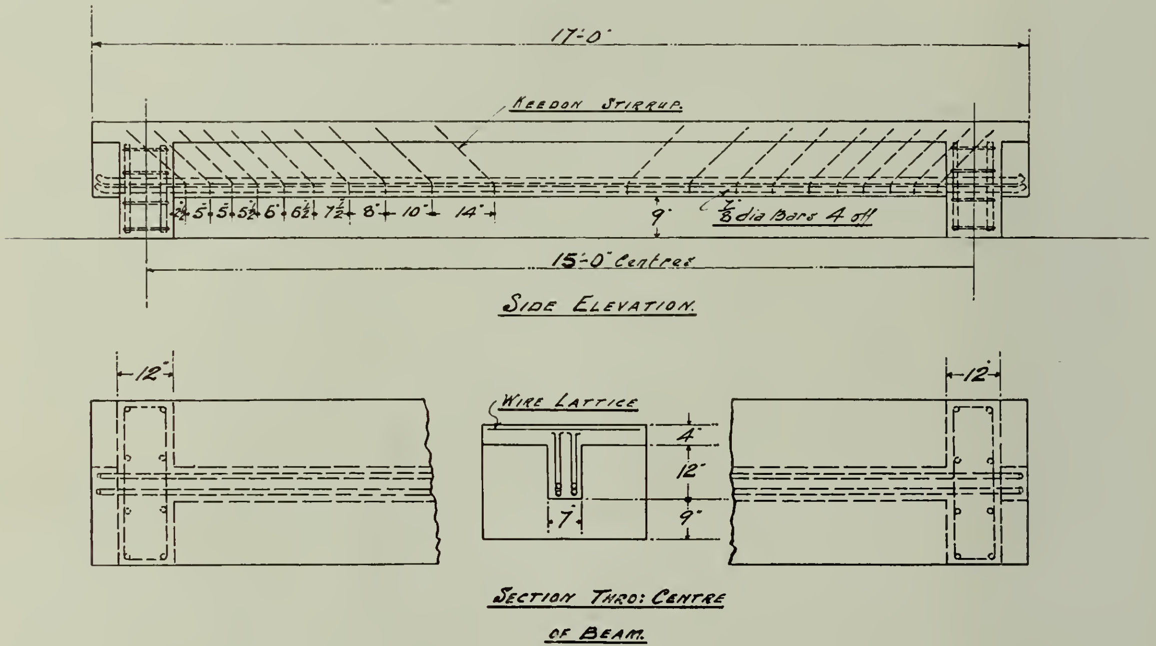
Both beams were built on April 7th, 1911. They had the same outside dimensions, the concrete was similar, and they had the same longitudinal reinforcements. The difference between the two beams lay in the arrangement of the shear reinforcement. In the first beam tested the shear reinforcement consisted of the usual U-stirrups, placed vertically, and not attached in any way to the main bars.

The second beam was provided with sloping stirrups, looped round the bars and keyed to them. The spacing of the stirrups was the same in both cases.

The main dimensions of the beams were as follows :

Width of slab forming top flange	3 ft.
Thickness of slab forming top flange	4 in.
Depth of web below slab	12 ,,
Width of web	7 ,,

There were four reinforcing bars near the lower surface of the web, each $\frac{7}{8}$ in. diameter.



Details of Test Beam 15 ft. Span Reinforced with "Keedon" Bars.

Each beam was tested on a span of 15 ft., the load being applied through two points on the top of the beam, each 3¾ ft. from the centre of the span. The following were the applied loads and the corresponding deflections of the centre point from the horizontal :

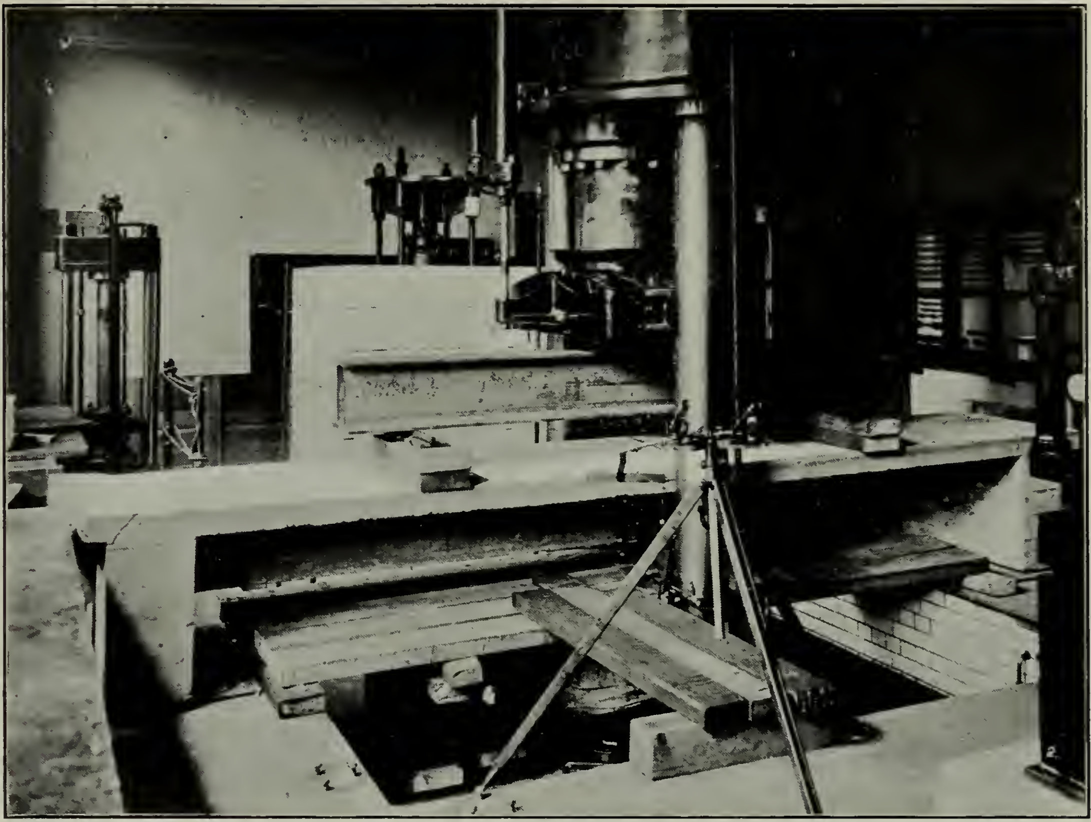
Beam No. 1. Test No. 3,035.
Tested June 20th, 1911.

Loads. Tons.	Deflection (corrected for zero). In.	
5	0·09	
10	0·19	Faint shear cracks began to show near the supports.
15	0·27	
20	0·36	
25	0·47	Shear cracks developed rapidly.
30	0·61	
32·2	Maximum load carried.	

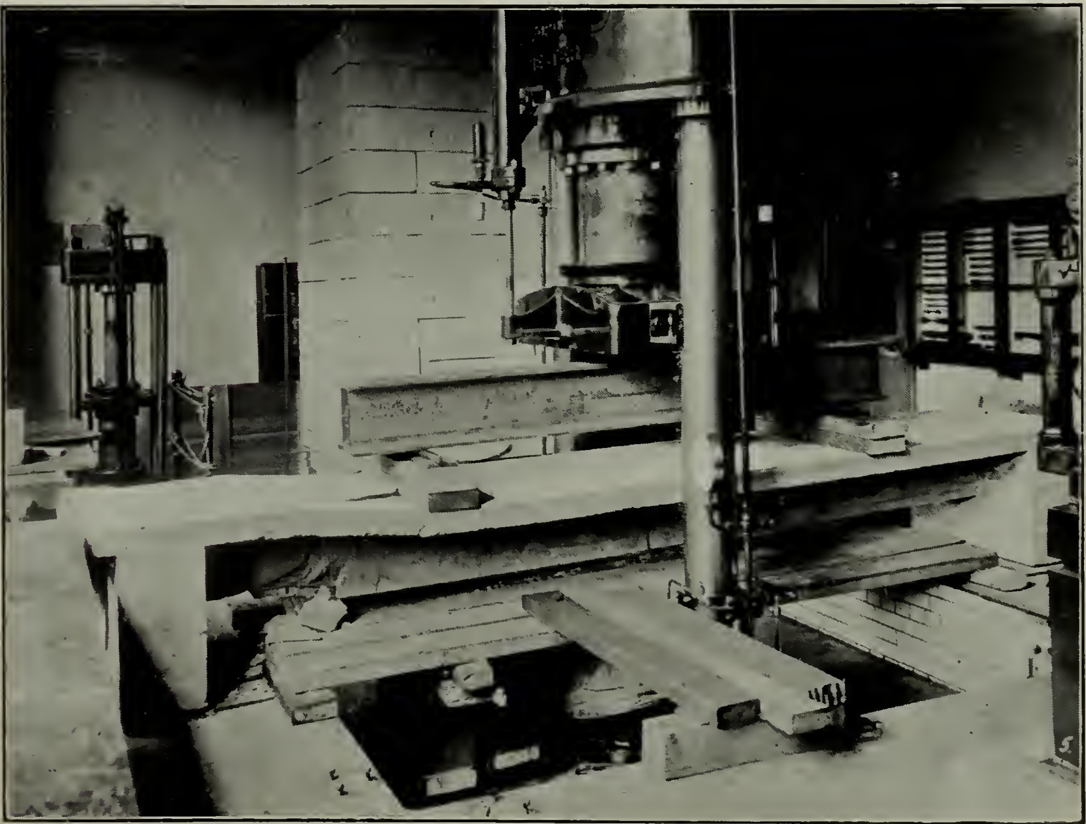
The beam failed by the above shear cracks extending and causing the beam to break through about 2 ft. from one support.

Beam No. 2. Tfst No. 3,043.
Tested June 27th, 1911.

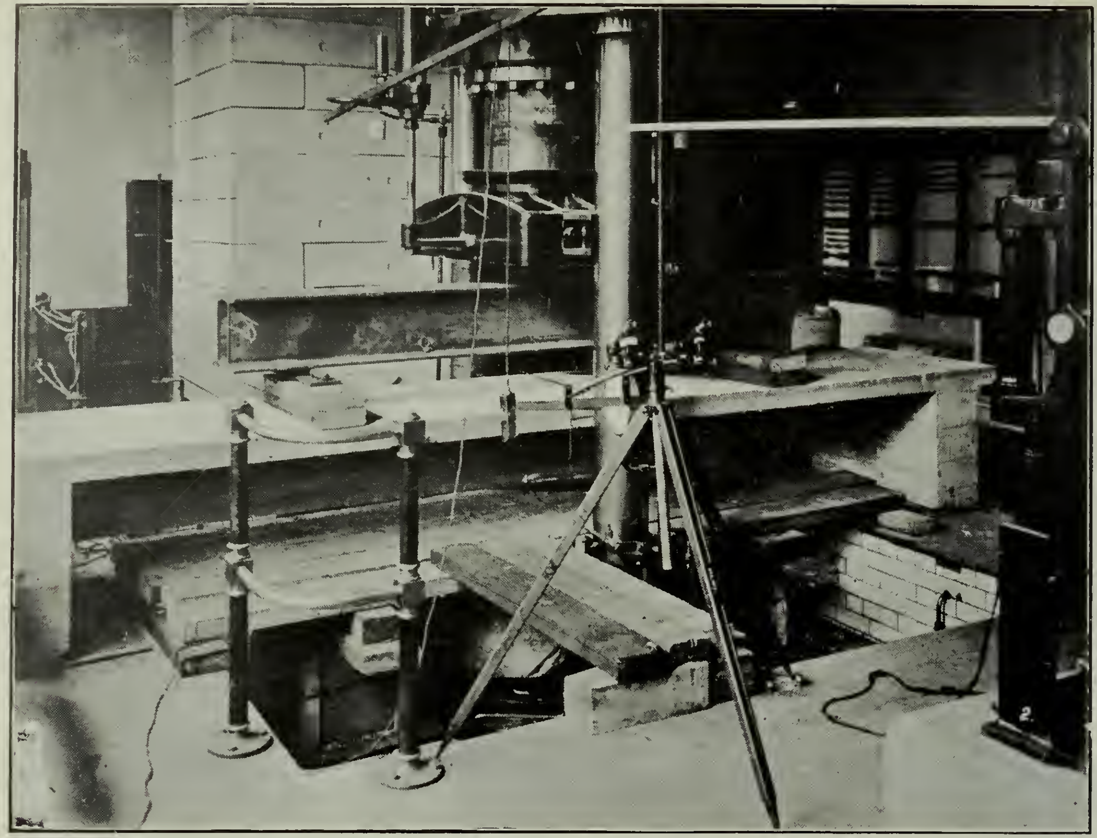
Loads. Tons.	Deflection (corrected for zero). In.	
5	0·09	
10	0·18	
15	0·27	
20	0·36	Faint cracks began to show near the supports.
25	0·45	Vertical cracks began to develop in the centre portion on the tension side. The cracks near support did not extend.
30	0·53	
35	0·64	
37·8	Maximum load carried.	



(Beam No. 1 was reinforced with U-*shaped vertical stirrups of same spacing as in Beam No. 2.)*
Beam No. 1 before Loading.

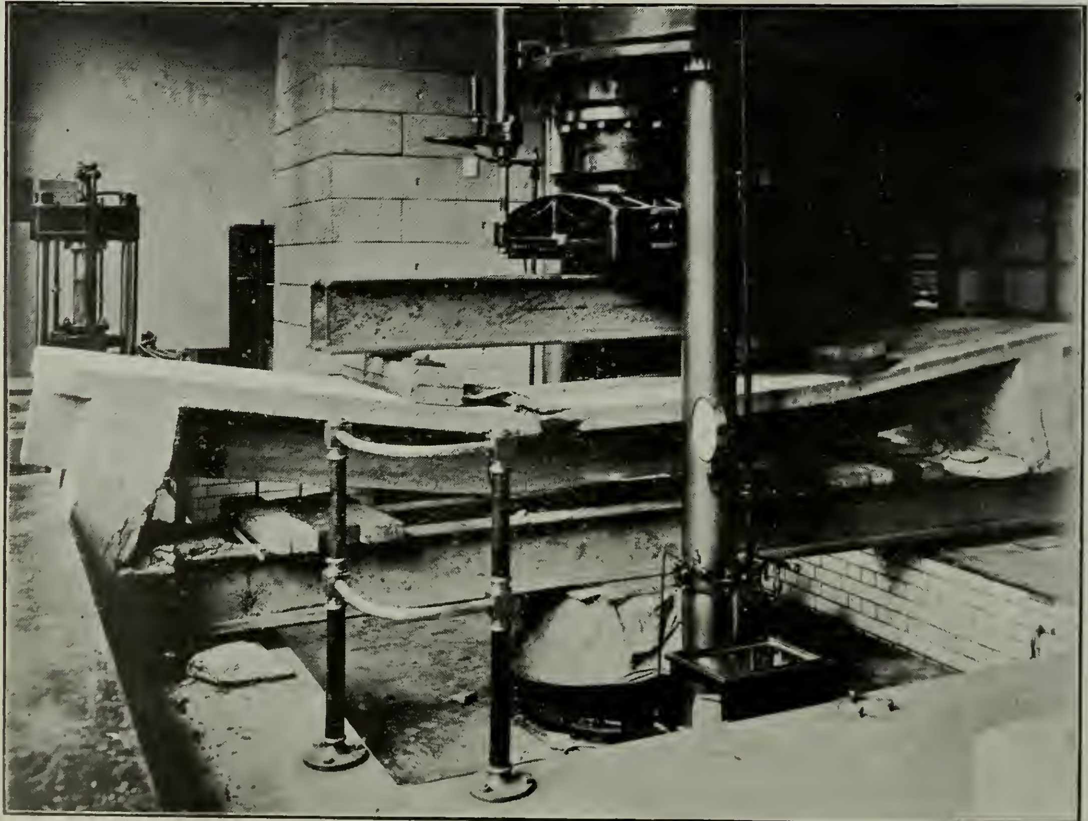


(Failure due to shear weakness at one end. No cracks whatever were seen in centre.)
Beam No. 1 at Point of Failure.



(Beam No. 2 was reinforced with "Keedon" stirrups inclined at an angle of 45° and spaced similar to stirrups in Beam No. 1.)

Beam No. 2 before Loading.

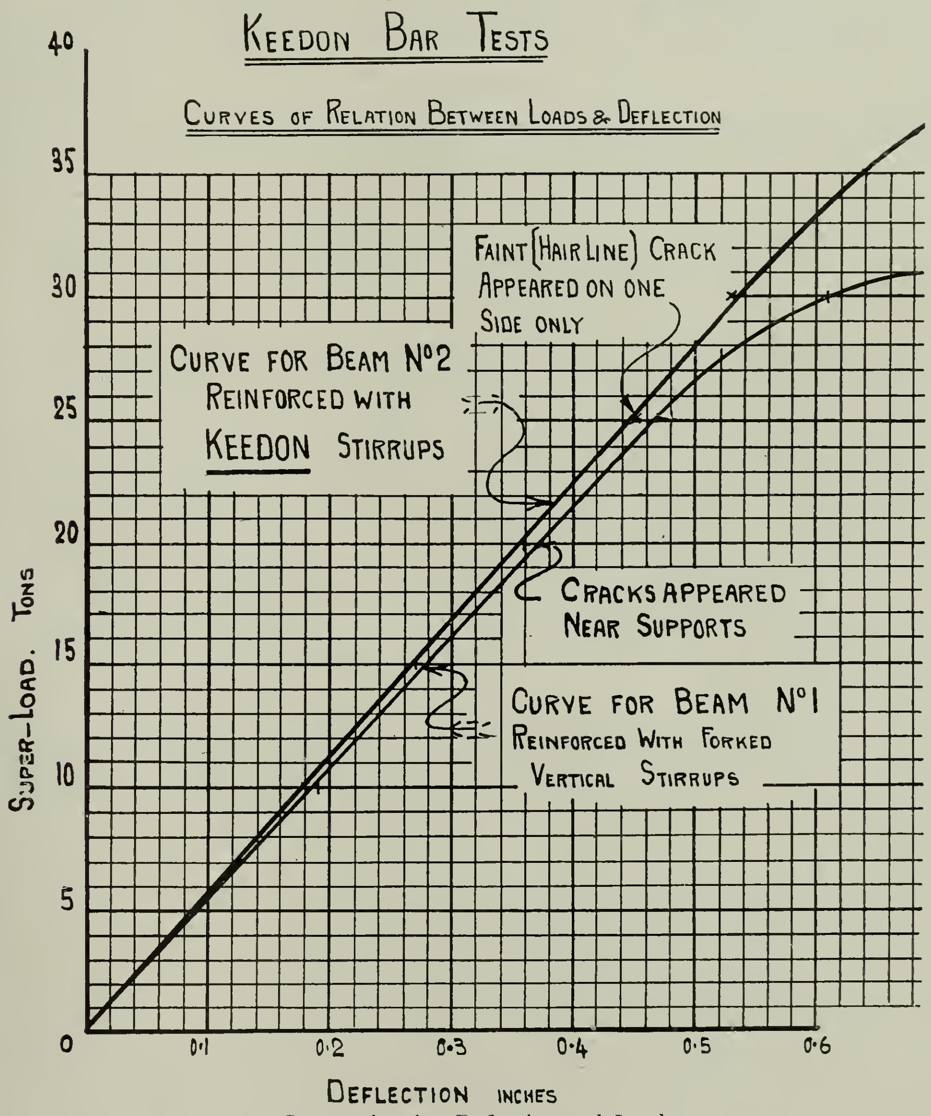


(Failure due to tensional and compressional stresses, no signs of shear weakness being observed.)

Beam No. 2 at Point of Failure.

Failure took place by the further development of the cracks on the tension side of the web. It is probable that the main reinforcement was strained beyond its yield point. In this beam the faint cracks first detected in the neighbourhood of the supports did not develop further before the maximum was reached.

(Signed) W. C. Popplewell, A.M.Inst.C.E.
J. T. Nicolson, M.Inst.C.E.



Curves showing Deflection and Loads.
Tests on Beams.

STEEL.

Tests were also carried out by the Manchester School of Technology on the steel used for bars and on the wire used for both forms of stirrups, and their report was as follows:

Report on Tensile Test of Six Samples of Steel.

Test No.	Mark.	Diameter.	Cross-section in sq. in.	Yield Point. Ton, sq. in.	Maximum.	Elongation on 2 in	Reduction in Area, per cent.	Remarks.
3,048	7	0·564	0·250	19·50	28·20	39·5	63·0	First consignment.
3,049	5	0·564	0·250	22·20	28·00	36·5	62·8	First consignment.
3,050	3	0·564	0·250	21·60	28·10	36·5	62·2	Second consignment.]
3,051	4	0·564	0·250	20·32	28·60	36·5	61·0	Second consignment.
3,058		0·249	0·049	39·80	45·70	11·5	62·6	From long stirrup (Keedon)
3,059		0·247	0·048	37·50	41·04	12·5	62·0	From short stirrup (ordinary)

Test carried out by Messrs. W. C. Popplewell, A.M.Inst.C.E., and J. T. Nicolson, M.Inst.C.E.

From these results it will be seen that the average result of steel bars = 28·2 tons per sq. in., and for the wire used in stirrups = 43·37 tons per sq. in.

Concrete.

The concrete consisted of 3 parts granite chippings ($\frac{3}{4}$-in. mesh), 2 parts sand, and 1 part cement. Four 6-in. cubes were moulded from the same mixing, and at the same time as the beams were tested to obtain the actual crushing strength of the concrete in the beams.

REPORT ON CRUSHING TEST OF FOUR SAMPLES OF CONCRETE (6-IN. CUBES).

Test No	Mark.	Load at First Crack.	Load at Crushing.
		Tons.	Tons.
3,044	1	22·5	22·5
3,045	2	26·5	31·3
3,046	3	24·4	24·4
3,047	4	30·2	32·9

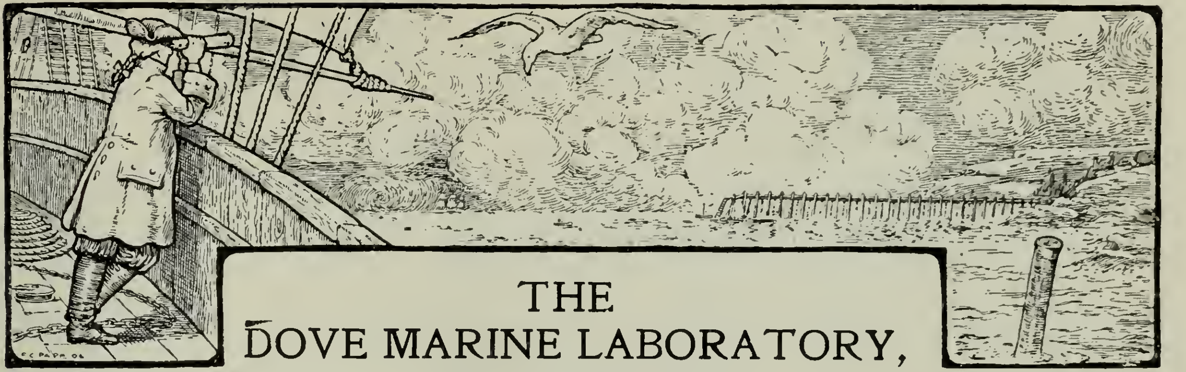
Test carried out by Messrs. W. C. Popplewell, A.M.Inst.C.E., and J. T. Nicolson, M.Inst.C.E.

The average crushing strength from these results = 1,740 lb. per sq. in.

The first beam, reinforced with loose vertical U-shaped stirrups, failed at 32·2 tons, whereas the second beam, of similar dimensions throughout, carried a load of 37·8 tons. To these figures must be added the weight of the beam itself, which equalled 1·45 tons, bringing the respective total load up to :

First beam (vertical U-stirrups), 33·65 tons ;
Second beam (Keedon stirrups), 39·25 tons.

This represents an increase of 5·6 tons, or 16·8 per cent., without any increase in dimensions and cost.

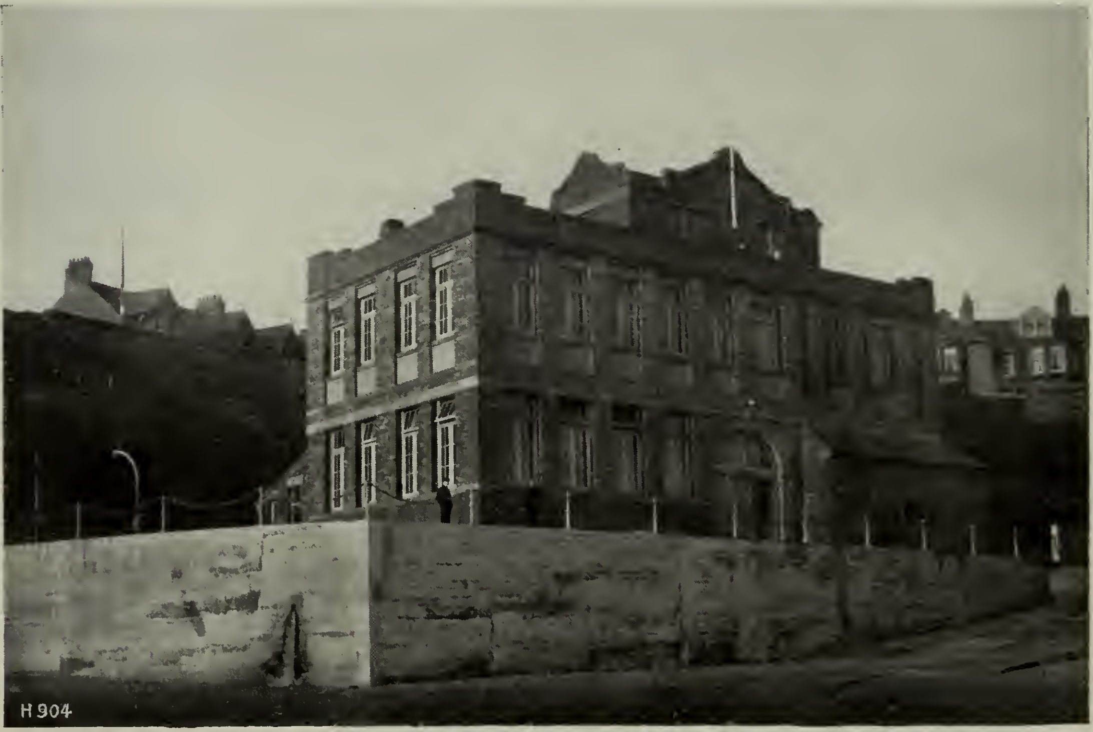


THE DOVE MARINE LABORATORY, CULLERCOATS.

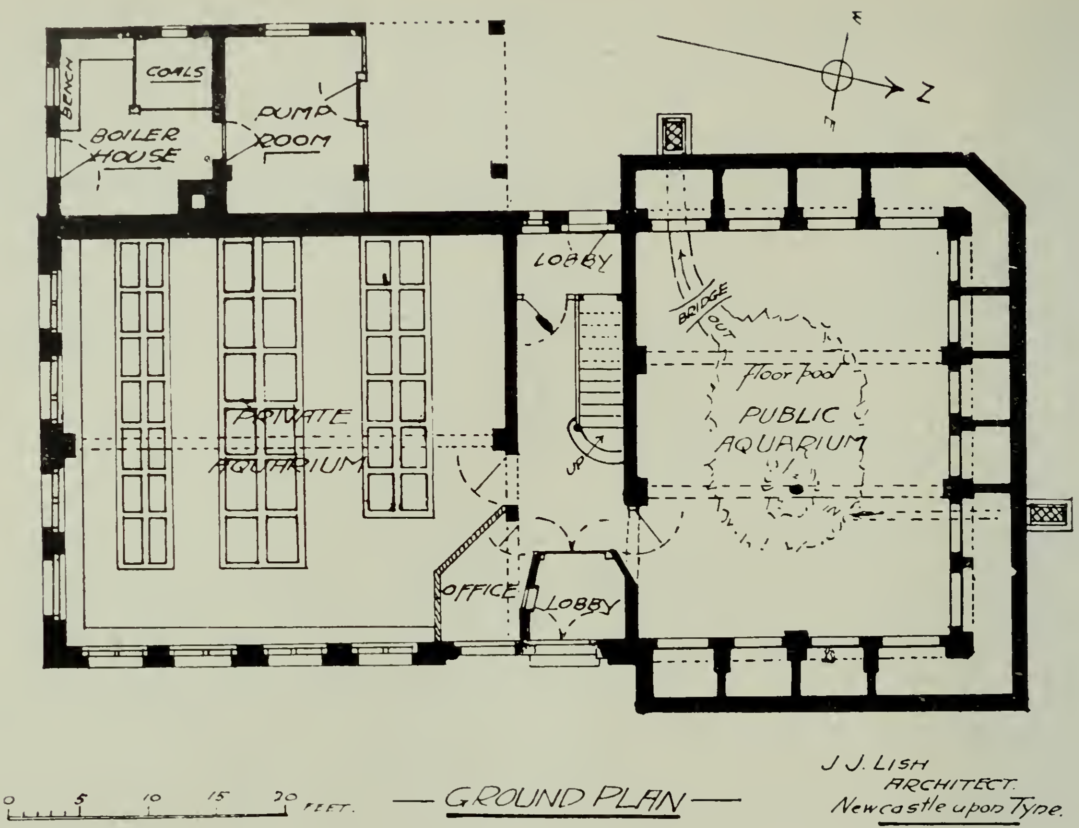
The following particulars of the reinforced concrete work at the Dove Marine Laboratory, Cullercoats, should be of interest to our readers, as showing the suitability of these materials for laboratory work, where cleanliness is of the utmost importance.—ED.

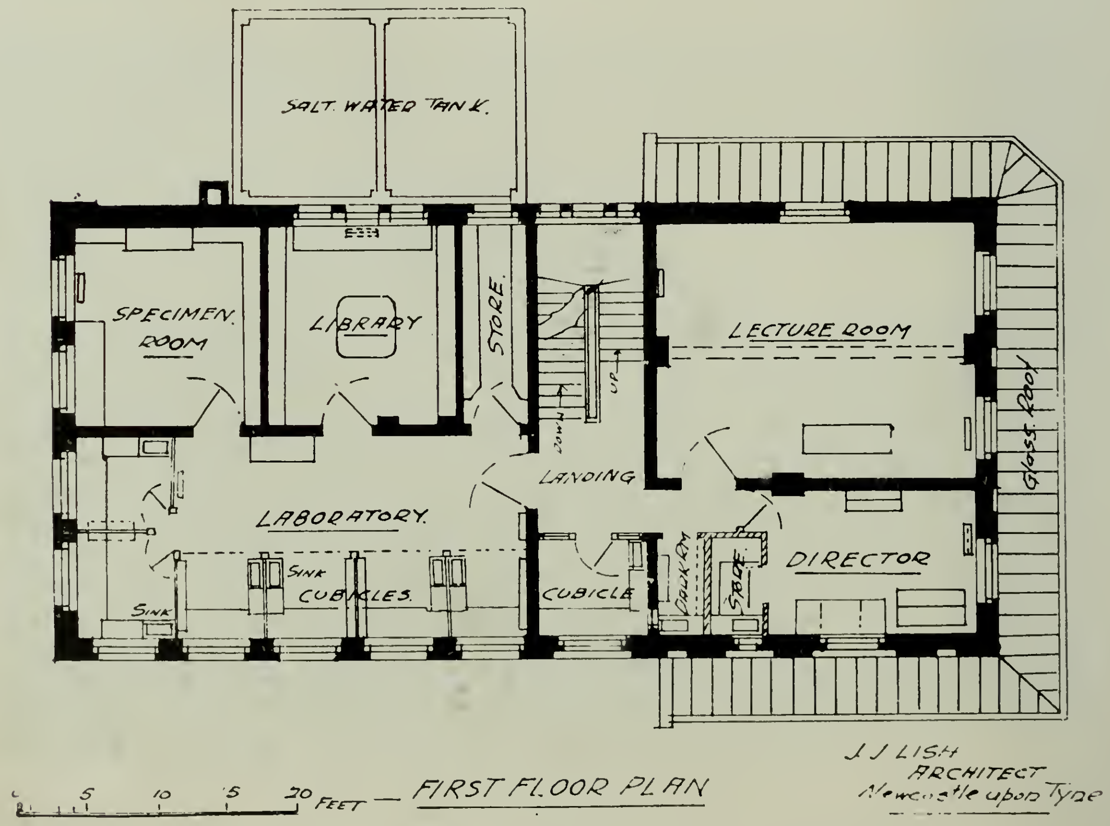
THE present laboratory was built to replace a one-storey wooden erection which had been utilised by the Armstrong College for the study of Marine Zoology, and which was burnt down in 1904. The new laboratory is a permanent structure worthy of the important branch of the scientific work for which it is utilised.

The site on which the building was to be erected was bounded on two sides by a quay wall, but owing to the extremely dilapidated condition of its wooden piles it was necessary to erect an entirely new one in its place. For this purpose a carefully designed structure of reinforced concrete, on reinforced concrete piles, was determined on. The section of this wall is in the form of the letter "L," the upright portion forming the "curtain," whilst the horizontal portion is the "slab," which, when opposite the highest portion of the wall, is about 9 ft. wide.



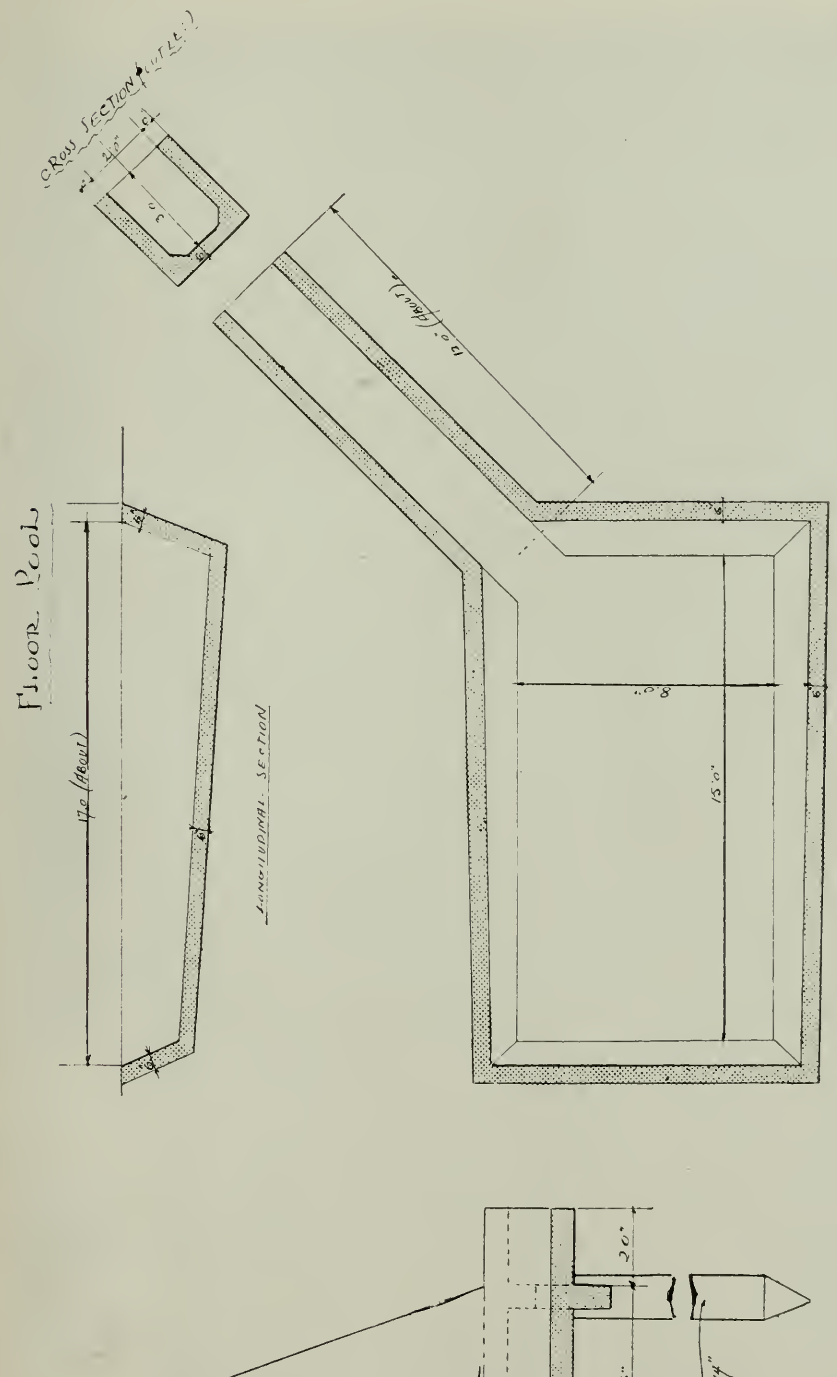
View of Completed Building and Reinforced Concrete Quay Wall.
THE DOVE MARINE LABORATORY, CULLERCOATS.





Plans of Ground and First Floors.
THE DOVE MARINE LABORATORY, CULLERCOATS.

The horizontal slab, which is continuous throughout the whole length of wall, is connected to the curtain or upright portion by buttresses, filling in the space from the extremity of the horizontal slab to the top of the curtain wall, at distances of 9 ft. or 10 ft. apart; the curtain portion of wall resting on the heads of the reinforced concrete piles.

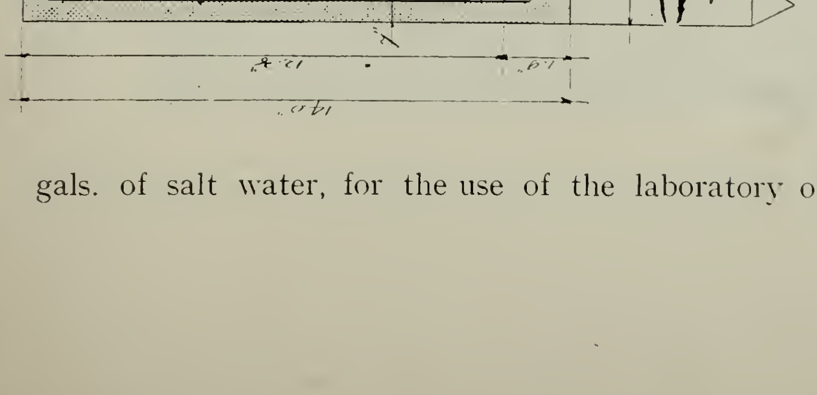


Plan and Section of Floor Pool.

The Dove Marine Laboratory, Cullercoats.

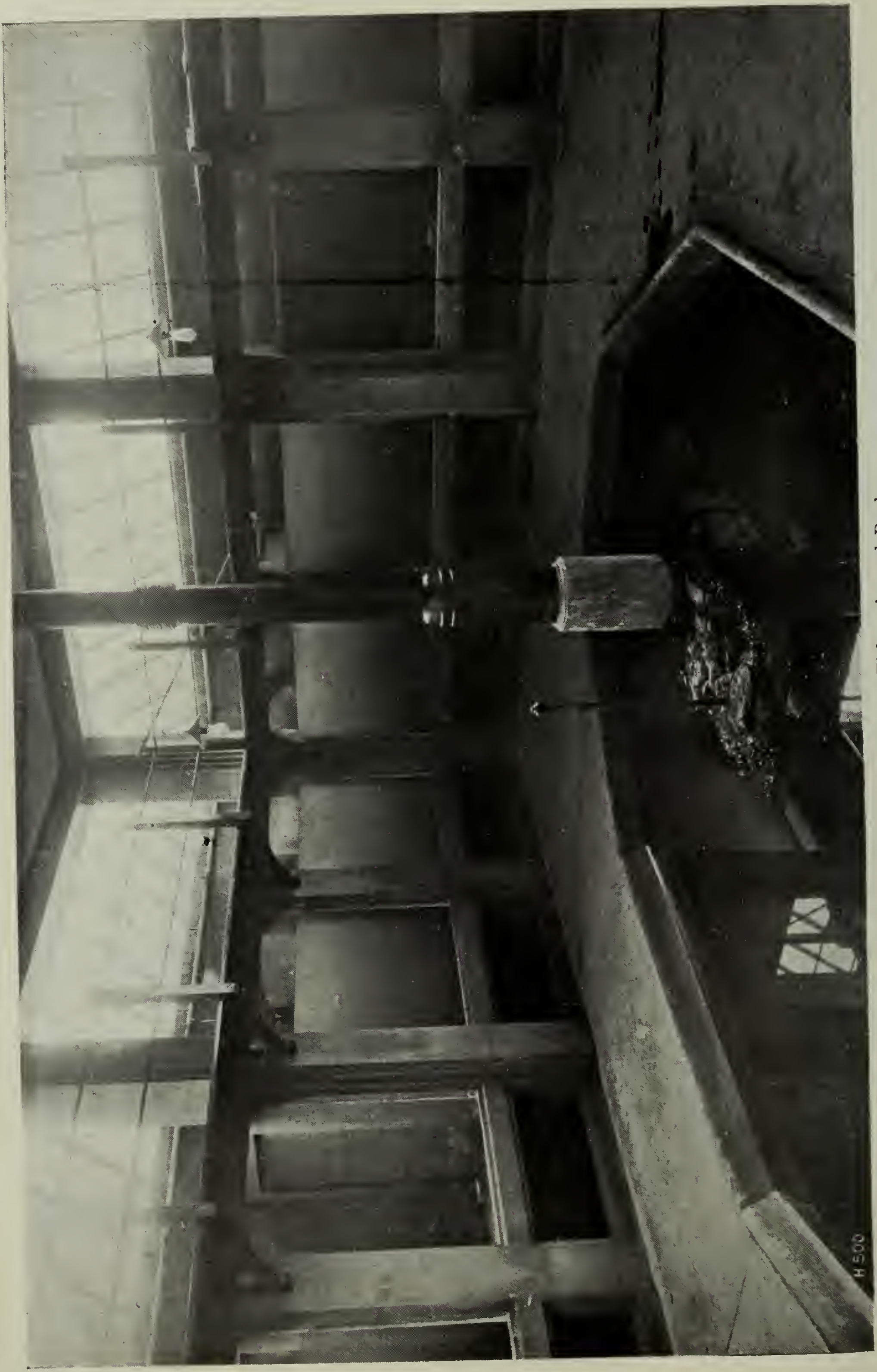
The aquarium is 30 ft. by 23 ft., and ranged outside of this are eleven fish tanks of varying sizes, projecting beyond the main walls of the building so as to secure direct vertical light and to obviate shadows. In the centre of the aquarium is a spacious floor tank.

The private aquarium is 32 ft. 6 in. by 30 ft., and has three double rows of aquaria, divided into 38 tanks, for the storing of materials, experiments, etc. Along the east and south walls is a concrete table or bench for experiments.



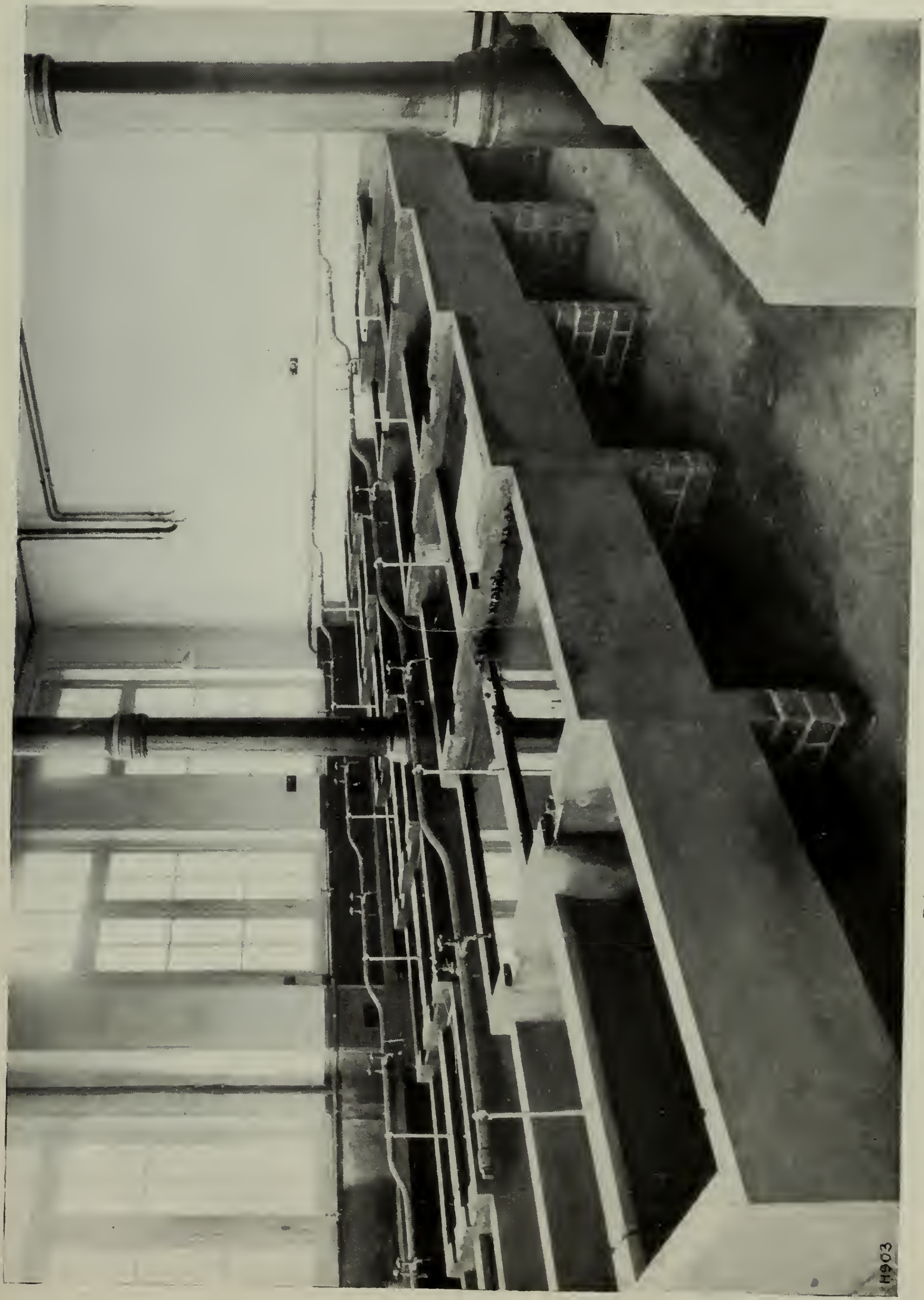
Section of Retaining Wall.

On the south-west corner of the roof is a concrete tank to hold 2,000 gals. of salt water, for the use of the laboratory on first floor. Against the west wall of the building there is another concrete tank, holding 15,000 gals. of salt water.



Reinforced Concrete Fish-tanks and Pool.
The Dove Marine Laboratory, Cullercoats.

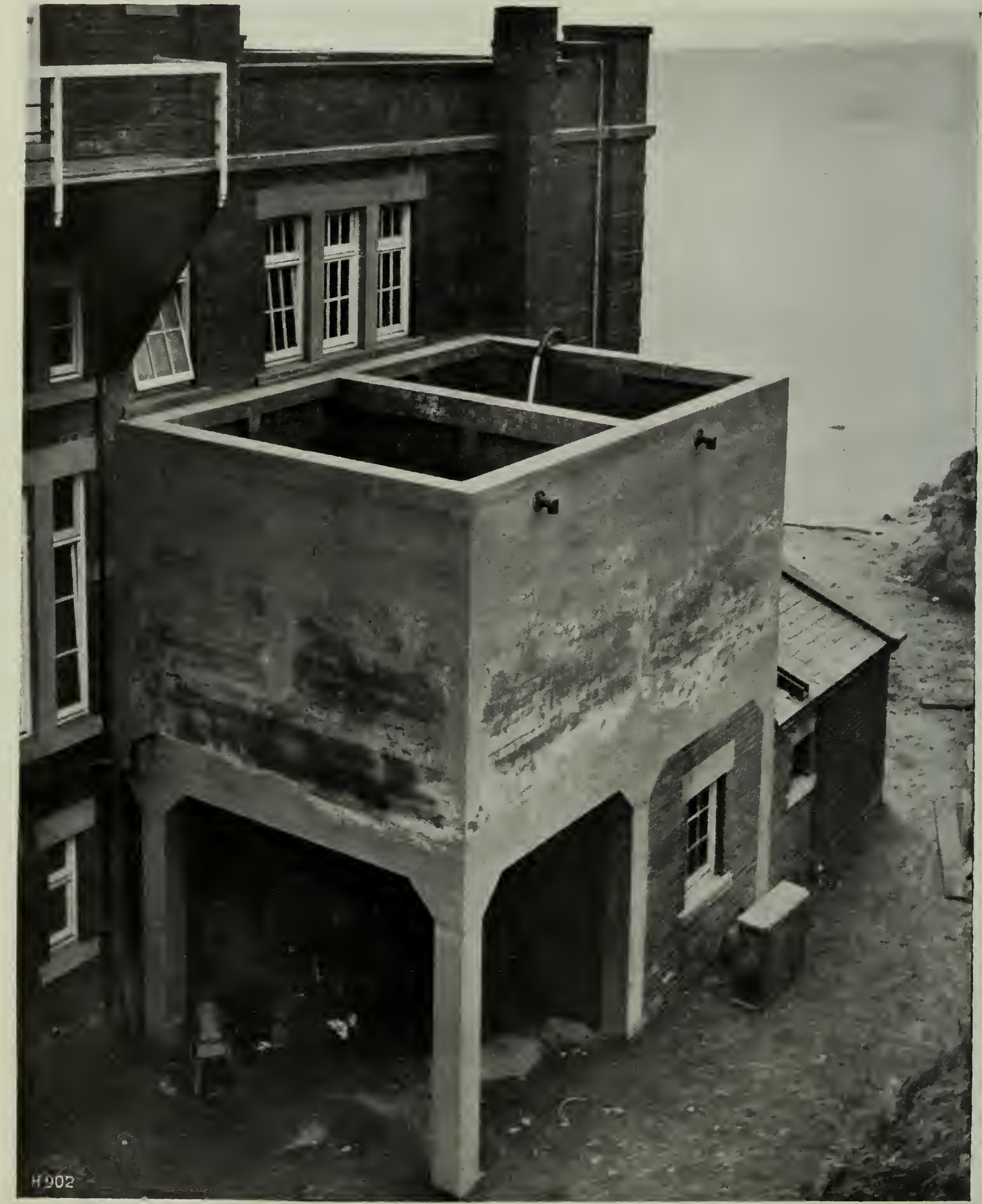
The public aquarium rests on a slab of concrete heavily reinforced, and all storage tanks, fish tanks, and the entire foundations of the building, together with the quay wall as before mentioned, were carried out in rein-



Private Aquarium, built of Reinforced Concrete on Brick Piers.
THE DOVE MARINE LABORATORY, CULLERCOATS.

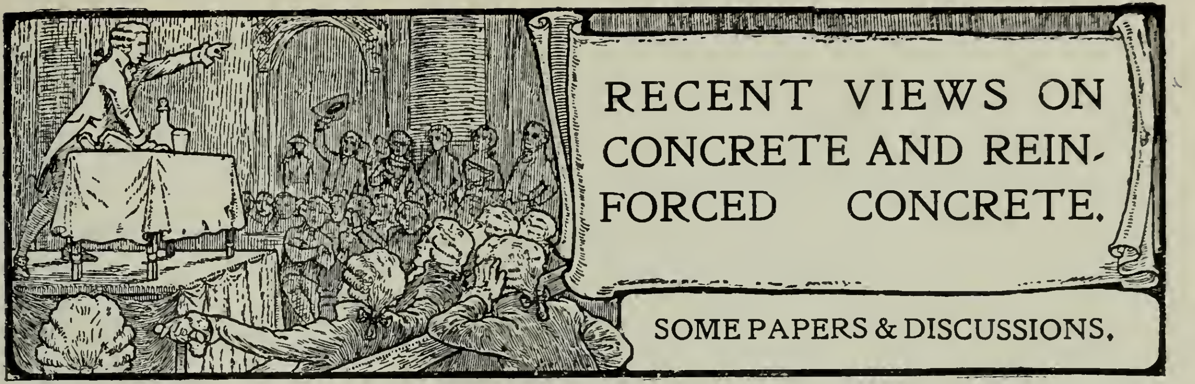
forced concrete on the Hennebique system by Mr. David Purdie, contractor, of Newcastle-on-Tyne. The foundations of the cast-iron columns are in cement concrete carried down to the solid rock. The architect for the work was Mr. J. J. Lish, of Newcastle-on-Tyne.

The building is heated throughout with hot water and on the second floor are retiring rooms with very complete lavatory arrangements.



Reinforced Concrete Salt Water Tank.
THE DOVE MARINE LABORATORY, CULLERCOATS.

In a very interesting book on " The Dove Marine Laboratory," the architect, Mr. J. J. Lish, gives an account of the structural details of the building, and also appends a short treatise on Reinforced Concrete and Portland Cement.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers ana Discussions presentea before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE ROYAL SANITARY INSTITUTE.

THE INFLUENCE OF BUILDING REGULATIONS ON ARCHITECTURE.

Paper by H. D. SEARLES-WOOD, F.R.I.B.A., F.S I.

At the recent Congress of the Royal Sanitary Institute in Belfast, among the many interesting papers presented was one by Mr. H. D. Searles-Wood, F.R.I.B.A., on "The Influence of Building Regulations on Architecture," an extract of which is given below.

In modern building regulations three things are considered—1st, the prevention of the spread of fire; 2nd, the construction of the building to guard the safety of the public; and, 3rd, public health.

Fire Prevention.—It is the regulations that deal with the prevention of the spread of fire that have had the greatest influence on the architecture of the period.

The regulations passed after the Great Fire of London set the fashion for brick and stone-fronted buildings which altered the appearance of all the towns in the kingdom, and in more recent times the Metropolitan Building Act, which was the first set of building regulations that seriously dealt with the problem of the prevention of the spread of fire, made marked changes in the architecture of the nineteenth century. The 4½-in. reveal to all windows and doors, and the restrictions as to baize boards and wooden cornices and the parapets to the party walls, are the marks of this set of regulations.

The rules laid down in the Metropolitan Building Act of 1854 for dealing with the rights of the building and adjoining owner of a party wall have worked so well that it is surprising no other city or town has adopted the same system. The system is, briefly, as follows:

Party Walls.—When a building that has party walls is about to be rebuilt the building owner serves on the adjoining owner's party wall notices which describe the work that is to be done to the party walls, and in this notice the building owner appoints a surveyor to represent him. If the adjoining owner does not agree within fourteen days of the service of the notice, a difference is said to have arisen, and the adjoining owner appoints a surveyor to represent his interest, and these two surveyors meet and appoint a third surveyor.

The first two surveyors then examine the party structure and draw up an award in which is set out the work that has to be done, and when this award is signed by the two surveyors it is published, and the matter is settled. Should the two surveyors not be able to agree on an award the third surveyor is called in, and within seven days he has to appoint a day for a hearing, and the three surveyors meet, and any two of them can agree on an award, which when signed by the two is published and becomes a binding document, only to be upset on appeal before a magistrate. The position of the third surveyor is not quite that of an arbitrator, he is only equal in rank to the other two surveyors, but it has been found to work well, and many awards are made by means of the third surveyor which could not be made between the two surveyors in the first instance. The third surveyor, being quite impartial, can complete the award which one of the interested surveyors would not care to sign. This method of dealing with a difficult situation is really a good help to architecture, and some such system should be part of the statute law. At present the law on the subject is that the party structure is common to the two parties, the building and the adjoining owner's, and it cannot be touched without the assent of both parties, and there is no means of compelling this consent. It is in this respect that the London practice has such great advantages.

There is a tendency nowadays to complain that the model by-laws are too severe, and that they prevent the building of cheap cottages and elementary schools. At the first exhibition of cheap cottages at Letchworth, the cottage that won the first prize was in accordance with the model by-laws in every particular. In going round the numerous Garden City developments, the only two things in the by-laws that appeared to increase the cost were the height of the bedroom stories, where 9 ft. is insisted on, and the height of the studded walls, which is also regulated by this by-law. In places where the story is 8 ft. the available area is also increased, and there does not appear to be any serious sanitary point in requiring 9-ft. stories.

The Building Acts and model by-laws are all based on brick construction ; the introduction of skeleton steel construction and reinforced concrete necessitates some changes in these Acts and by-laws.

Reinforced Concrete Construction.—The Royal Institute of British Architects have just issued a second edition of the Regulations for Reinforced Concrete Construction, which are the standard for such method of building in the British Empire. This revised edition will be the basis of the Regulations about to be issued by the London County Council, and will be dealt with very much on the lines of their Regulations for Skeleton Steel Construction, which are in their Act of 1909. The principle is that the calculations on which the steel construction has been designed are submitted, with the drawings, to the district surveyor, who checks the calculations before the plans are approved. These calculations can be made in any form that is recognised by the profession ; but a good method of tabulating the calculations has been drawn up by the District Surveyors' Association and approved by the Royal Institute of British Architects, and it is a great saving of time and labour if the information is given by the architect to the district surveyor in this form.

The Regulations for Reinforced Concrete give the tests to be applied in selecting the materials, and the methods of calculating the various parts of the building, the method of mixing the materials, and the precautions that have to be taken in preparing the centering and carrying out the work.

Some people are of the opinion that the time has come when there should be a general Building Act for the whole country ; let us hope if this comes to pass that it may be so drawn as not to stereotype existing methods of construction, but stimulate new and better methods than at present. It might be a good thing to encourage architects to work out the strains and stresses in their structures by making a law that the methods of calculating the designs should be submitted to the District Surveyor, and if found correct the construction should be allowed, and thus do away with all those cast-iron schedules and rules that so often hamper an original design.

It may be said that these are matters which do not directly influence architecture, but with the introduction of new materials and methods of construction, new means of expression must be found. It is true that over 4,000 years ago men were using the same materials as are now commonly in use, but during that time what varied expression has been given to the use of these materials ! Each succeeding race has written its history in monumental works that are our most cherished possessions, and we in our time must strive to leave behind us some monuments worthy of the age in which we live.

DISCUSSION.

Mr. Brodie (Borough Engineer, Blackpool) said he would welcome anything which would simplify the laborious duty of specifying by-laws, for it often happened that in the most carefully drawn-up building by-law points which arose were not covered. It would be a great mistake for any new Building

Act to come up for the whole of Great Britain and Ireland which laid down minutely what ought to be done. All they could attempt was general principles covering the safety of a structure, and also the health of the people who had to occupy the building, whether it be a dwelling-house, or a large meeting place, or a warehouse.

Mr. E. T. Hall thought if they were going to lay down cast-iron rules they would prevent experiments in new forms of building, and by stereotyping rules and regulations they would render it very difficult for the architect who had got some new method of expressing himself to give effect to that. The gravest objection he had ever heard to the present system was that if they left it to the discretion of those who were carrying out the Act they were leaving it to an unknown quantity. The great majority of the men who had the final carrying out of the Act were men of great common sense and great experience, but it was within the knowledge of everybody that occasionally they came across men who had not the training and who were not gifted with common sense, and these men were obstructive and troublesome. It was because of such men that many persons had sought refuge in having strict regulations laid down. He felt with the author that it would be a great blessing if they could get rid of the costly litigation and obstruction and confusion which arose from light and air cases.

Mr. Cutler (City Surveyor, Belfast) said that he recognised the advent of reinforced-concrete building was enormously increasing the surveyor's labour. It was not possible for the ordinary staff employed in the inspection and supervision of buildings to have the necessary knowledge to make the calculations which must be gone through to see that any design was safe. He knew that such buildings had come to stay, and if there were many buildings of reinforced concrete put up in Belfast he would have to have an addition to his staff to deal with the scientific problems which arose. With regard to the building by-laws in general, he considered the more cast-iron they were the better, and he did not believe there were many by-laws for ordinary buildings which interfered with architectural practice. They must not forget that the bulk of the buildings in any town or city were not put up for architectural beauty, although he admitted they might well be. Building by-laws were absolutely necessary for the control of those who were not accustomed to architectural problems. He could quite understand the architect's point of view, but when they had to deal with the jerry builder, and with the many men who did not even employ a builder, but put up buildings under their own supervision, then the more cast-iron the rules were the better. In Belfast, although they had no by-laws for regulating steel and reinforced-concrete buildings, yet they had used such discretion as was necessary in dealing with these structures. They had not enforced the by-laws with regard to the thickness of walls, and they had given facilities to those who wished to use such materials, and the Committee had met every case in a reasonable way.

Mr. Lacey (Oswestry) said there was nothing in the building by-laws which had any bad effect on architectural features. He did not think the by-laws for brick and stone buildings were too severe, for they only took the minimum so far as the safety of the building was concerned. Certainly they were below what the minimum ought to be with regard to air space and sundry other matters which would affect the health of those who had to live in the buildings. At the same time he agreed that statutory powers should be given to local authorities, which they had not at present, to allow for steel construction and reinforced-concrete buildings.

Mr. W. H. Wyhatt (Grimsby) remarked that, whatever they put in by-laws, there were some builders who would try to get below them, and he quite agreed with the views of Mr. Cutler. London differed from the provinces in building, especially with regard to the quality of the bricks used, and the code as to the thickness of brick walls was probably correct for London. The model by-laws were, however, too severe for the provinces, and they felt that they could build a 9-in. brick wall 8 ft. or 9 ft. higher than could be safely done in London. In London most of the houses were three or four stories, and it was necessary to carry the party wall through the roof as a protection from fire. In the provinces the houses were two or three stories, and it was quite unnecessary that there should be the great cost of carrying the party wall through the roof. Personally, he felt it was a great mistake to give the officials any discretion at all with regard to the enforcement of by-laws. A builder would come and plead a special case, and the surveyor might feel inclined to give way on a point, but they knew perfectly well the builder would tell somebody else, and then others would come and want a relaxation of some other rule. Therefore, he felt that the by-laws should be as definite as possible.

Sir Henry Tanner said that he was practically free in all his building construction from by-laws, but he would rather go for latitude as far as possible in all by-laws, and allow plenty of elasticity. As to reinforced concrete, he did not think they could make any rules which would cover everything, and thus, as far as possible, that should be left an open matter. They did not seem to have mistakes in construction, for the buildings stood right enough. On the whole he preferred that each case should be dealt with as it arose. Even if they took the rules which the author had handed round, they only applied to particular points as to corridors and columns, and so on, but no mention was made of any sort of connection between the several things, and yet it was one of the most essential things in reinforced concrete construction.

Mr. P. C. Cowan (Irish Local Government Board) said on his shoulders lay the duty of revising the general building by-laws of Ireland, which followed the English code very closely. Mr. Searles-Wood did not tell them what grievance the architect had, or what effect the by-laws had on architecture. He ventured to submit that the building by-laws of Ireland could have no prejudicial effect on any reputable architect's practice, and he was absolutely certain from experience that any relaxation with regard to common ordinary buildings would be a great and gross mistake. He agreed that it was not possible to put into short, crisp by-laws regulations for reinforced-concrete buildings, and that the submission of the full plans with full calculations for revision and approval by the local authority was the proper line to take. Except in one or two large towns, there was no power for a local authority in Ireland to waive its by-laws.

Mr. Searles-Wood said he would not attempt to answer the points raised, but he had been successful in disguising his own feelings in regard to by-laws. As an old district surveyor for twenty-eight years he was quite in favour of by-laws, and he had never found any difficulty in meeting with the reasonable requirements of by-laws.

AMERICAN SOCIETY FOR TESTING MATERIALS.

PRACTICAL TESTS OF SAND AND GRAVEL PROPOSED FOR USE IN CONCRETE.

Paper by Mr. RUSSELL S. GREENMAN.

The Fourteenth Annual Meeting of the American Society for Testing Materials was held at Atlantic City, N.J., in June last, when a number of interesting papers were presented. Below we give an extract from that read by Mr. Russell S. Greenman.

THE selection of those elements which, with proper and intelligent workmanship, shall produce good concrete is certainly important, but how to secure and select the best materials is often a problem. Apparently good sands or gravels have been selected, but not always have lasting results been secured. The method of securing for the consumer a good and safe cement has been provided. The question of securing good aggregates has been provided for in many individual cases, but a campaign of education as to the need of careful selection of the aggregates and of instruction as how to select them is still generally needed. If it is true that the bulk of the cement now produced is used by the small consumer, then this applies especially to the smaller maker of concrete, and not so much to those in charge of large public works.

The selection of the materials for the concrete should be made only after careful examinations and tests, either in the laboratory or on the site of the work, or perhaps both. To aid this selection certain tests have been suggested and made. It will be found, however, that there are no standard tests or methods which can be used as a basis for comparable results.

We have before us, then, the question of tests and methods. These may be resolved into two classes—laboratory tests and practical field tests. The laboratory tests should be such that practical results and conclusions can be secured. The field tests should be made supplementary to the laboratory tests and confirmatory to them, and not as substitutes.

The selection of the coarse aggregates—crushed stone or gravel—is the more easily made, but sands and other fine aggregates do not so easily divide into good and poor materials. When reference is made to sands it will include, of course, all materials for the fine aggregate, such as natural sands, screenings, iron ore tailings, etc. Gravels generally can be considered as sands, and facts concerning the one usually apply to the other.

Sampling.—It is, of course, generally conceded that any testing of the constituent materials is all wasted energy unless the samples submitted are thoroughly representative. It is certainly no easy proposition to take, for instance, a sample of sand directly from the sand bank or pit; but if the tests are to be of real value provision must first be made for securing the representative sample. Sampling at the pit means that either the pit must be uniform or that extraordinary judgment must be used in selecting a sample typical of the sand, or gravel, generally in that pit. Undoubtedly the best sample from any pit is that taken from a blend made of samples taken at various places in the pit ; but in some cases, even with the most conscientious sampling, the pit sample may not be thoroughly representative of the sand as it is delivered upon the work. Therefore, whenever possible, the sample should be drawn from the sand hopper or taken from the sand pile after delivery upon the work. This sample, if accepted, should be kept as the standard, and future samples, whether taken at the pit or after delivery, should be expected to equal in qualities the accepted standard.

Laboratory Tests.—Having secured the sample, what are the most practical laboratory tests ? The test for strength of the mortar made with the sand and a "standard cement" is always a desirable test, but will not the tests for percentages of silt and of voids, and for size and grading of the sand grains, give results that form equally as good a basis for the acceptance or rejection of the sand ?

In order to consider the tests more fully without entering into a detailed consideration of the methods used in determining each result, I have adopted, for the present, as our standard the apparatus and the methods used by the Structural Materials Laboratory of the National Department of the Interior. Now, having selected a definite plan of testing in order to ascertain if these results have a practical value in determining the relative values of the different sands, we shall use the results secured in the laboratory of the Department of the State Engineer and Surveyor of State of New York. Selecting practically at random, and yet typical sands, thirty-four sands from over two hundred tested during the past two years, the following interesting results are noted :

TABLE NO. I.

No. Sands	Tensile Strength				Per Cent.		Class
	Natural		Washed		Voids	Loam	
	7 Day	28 Day	7 Day	28 Day			
10	217	305	201	301	32·0	4·1	A
13	167	271	155	249	33·4	3·3	B
11	121	208	123	212	36·6	2·2	C

TABLE NO. II.

Granulometric Test

No. Sands	Class	Per Cent. passing Sieves Nos.											
		2	4	6	10	20	30	40	60	74	100	140	200
10	A	100	99	98	89	69	47	29	14	8	3·8	2·3	1·6
13	B	100	99	98	96	87	72	56	31	17	5·8	2·6	1·6
11	C	100	100	99	98	95	79	60	38	29	7·5	3·6	1·6

TABLE NO. III.—EFFECT OF VOIDS.

Per cent. of Voids between	No. Sands.	Average per cent.	Tensile Strength.*		Per cent. passing No. 100 Sieve.
			7 Days.	28 Days	
25–30	5	27·8	192	310	2·8
30-35	17	33 0	164	256	6·4
35–40	11	37·8	140	220	6·7

* Results taken only of washed sample so that effect of loam would be nil.

TABLE NO. IV.—EFFECT OF LOAM.

Per cent. of Loam between	No. Sands.*	Average per cent. Loam.	Tensile Strength.			
			Natural.		Washed.	
			7 Days.	28 Days.	7 Days.	28 Days.
0–2·0	7	1·0	128	254	148	261
2·5–3·5	6	3·0	181	273	178	271
5·0–6·0	5	5·6	222	324	205	310

* Sands selected which had approximately the same percentage of voids.

A study of these results will show that a sand can be judged by its percentage of voids or of loam and by size and grading of its sand grains. As a general rule, it would be unpractical to make long time tests for tensile strength, so these tables give only the 7 and 28 day tests. Longer tests are, of course, desirable, but as we are now only considering practical tests we will endeavour to draw some conclusions from the tests at hand. We find that in Table I. the highest tensile strength is with the lowest percentage of voids and the highest percentage of loam, and that the natural samples containing more than 3 per cent. of loam are stronger than the washed sand. From Table II. we note that the smaller percentages of voids are secured by the sands having the best grading of the sand grains, and that the sands with the largest percentages of fine grains are the poorer. Table III. emphasises the fact that sands are the stronger when the percentage of voids is smaller, and that the less percentage of very fine grains the better the strength. Table IV. shows that loam to a certain amount is rather an aid to strength. This statement must not, however, be construed to mean that it would be advisable to permit certain large percentages of loam.

From this brief statement of the results secured and conclusions drawn it can be seen that each test is a very important aid in determining the quality of the sand under inspection. There are, of course, other laboratory tests which are of great importance in the selection of a sand. Among them is notably the careful examination of the character of the sand grains.

With a better knowledge of the best methods of conducting tests, and with a higher appreciation of the value of these tests among the general concrete contractors, and frequently among engineers themselves, then laboratory tests can be utilised to their full value. Scoffers of laboratory tests have only to examine results of the tests with concrete in which the sand has been used to see that the tests do forecast what does take place in the concrete.

Field Tests.—While it may be most practical and best to have the sands first tested in the laboratory, the greatest ultimate good to concrete in general would be to convince the contractor, and often the engineer, that simple field tests will also be of material benefit to the work. For example, frequent tests for density and for proportioning would have a most beneficial resultant. The contractor would not necessarily have to use more cement, but, on the other hand, he might be able by proportioning to produce a more dense concrete simply by addition of more either fine or coarse aggregates.

Such simple tests as the tests for percentage of loam by use of a graduated cylinder, or for the percentage of voids by means of the percolator, should be frequently made. Neither of these, for example, requires elaborate apparatus, and can be made in any field office, and yet how seldom in general work is any effort made to learn how much loam or how many voids a sand contains.

Cubes and cylinders made from the concrete as it is mixed make possibly one of the most satisfactory methods of securing good concrete. It is, of course, true that, to complete these tests, the best specimen must be tested in a laboratory. The results obtained would, however, result in one soon learning whether or not the concrete is as good as could be secured. It may be claimed that this is not a practical field test. It may not be for small work, but on large works it should be more generally used.

In conclusion, it should be again stated that the object of this brief paper is but to call attention of " concrete " men to the practicability of testing the sands and gravels proposed for use in concrete, and to the tests and the methods generally followed.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

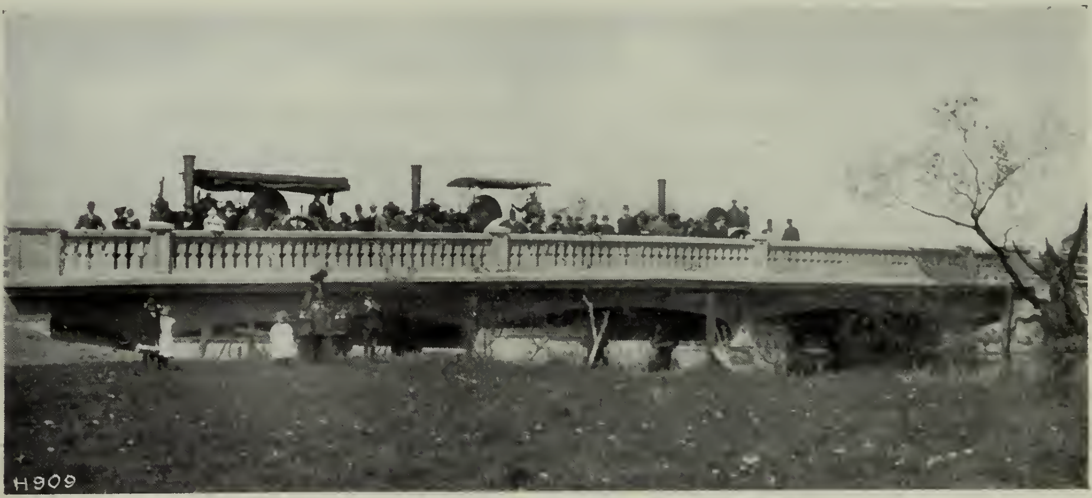
Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

REINFORCED CONCRETE BRIDGE OVER THE STOUR AT LONG MELFORD.

THE old timber bridge over the River Stour, forming one of the chief means of communication between the counties of Essex and Suffolk, has recently been replaced by a substantial reinforced concrete structure, an illustration of which appears on this page.

The reinforced concrete structure, which has taken about seven months to erect, owing to the delays occasioned by the floods during the winter of 1910–11, is built on Hennebique principles, the distance between the abutments being 100 ft., and the width between the parapets 25 ft., a footpath 5 ft. wide being formed on one side of the bridge only.

The main beams are arched, and are supported by twelve reinforced concrete piles, 18 in. square, spaced three abreast in three rows. The decking is $5\frac{1}{2}$ in. thick under the roadway, and 4 in. thick under the footpath, whilst the ornamental parapet, which is also in reinforced concrete, is $4\frac{1}{2}$ in. thick and 3 ft. 6 in. high. The abutment walls and wing walls under the approaches to the bridge are in ordinary concrete.



View during Test.

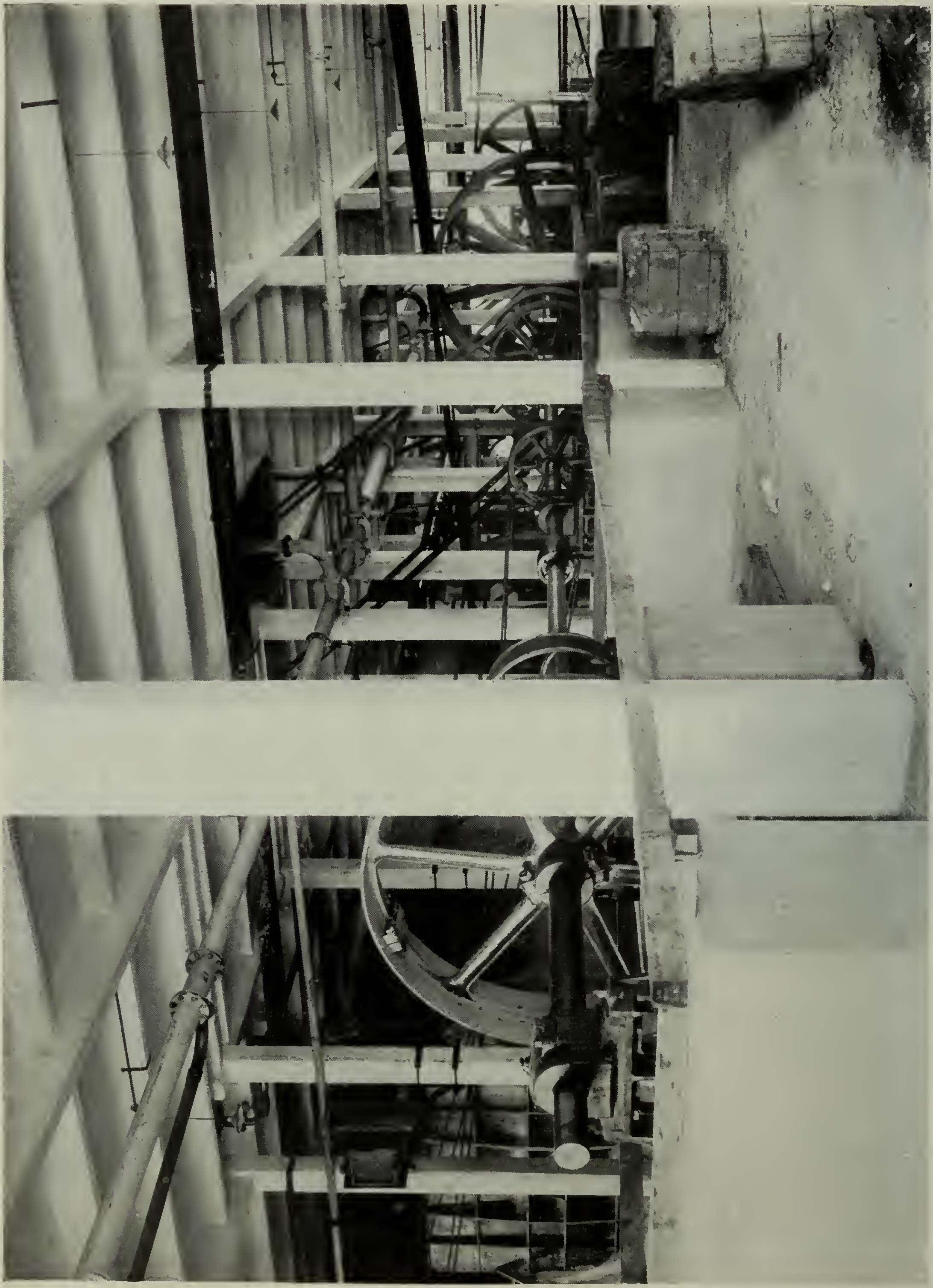
REINFORCED CONCRETE BRIDGE OVER THE STOUR AT LONG MELFORD.

The testing of the bridge was carried out by means of traction engines—first one, then two abreast, and finally three engines passing over the bridge together, making a total load of 35 tons. The results were exceedingly satisfactory, the maximum deflection being $\frac{1}{16}$ in. On the loads being set all the instruments returned to zero, no permanent set showing in the reinforced concrete work at all, the maximum deflection recorded being equivalent to $\frac{1}{5700}$ of the span, as against $\frac{1}{600}$ of the span allowed by the contract. As this bridge is a new form of construction for the district, the official testing was the occasion of a large assemblage of the two county councils concerned, including the chairmen of the respective Highways and Bridges Committees, Mr. P. J. Sheldon, Surveyor to the Essex County Council, and Mr. A. A. Hunt, Surveyor to the West Sussex County Council.

The reinforced concrete details for the work were prepared by Messrs. L. G. Mouchel & Partners, of Westminster, the whole of the work being carried out by Messrs. Holloway Bros. (London), Ltd., Contractors, of Lambeth, S.E.

REINFORCED CONCRETE WORK AT THE IMPERIAL PAPER MILLS, GRAVESEND.

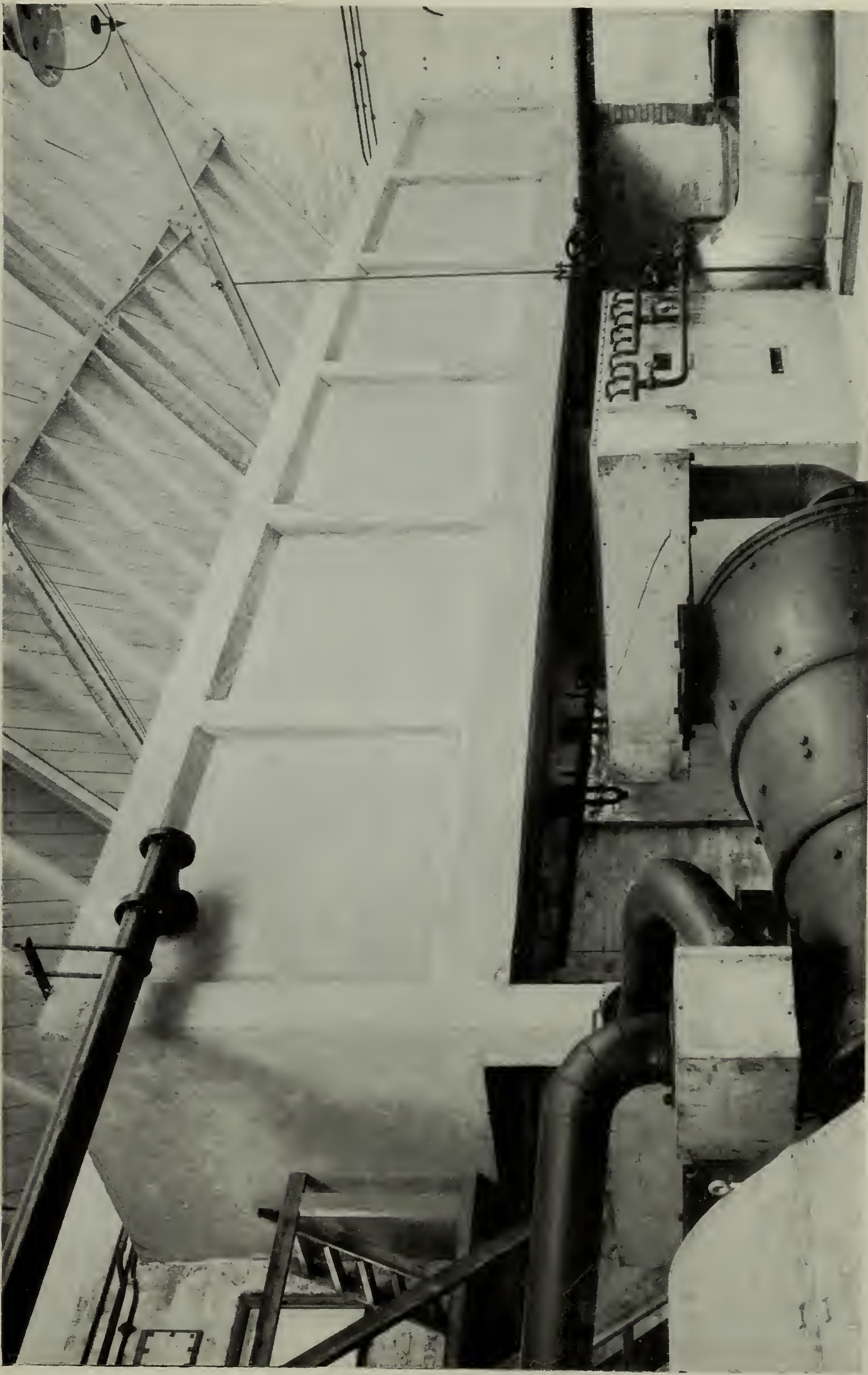
THE Imperial Paper Mills, at Gravesend, have been erected and equipped in fifteen months, and will have an output of about 2,000 tons of paper per week. The mills are one of the finest structures of the kind in existence, and cost about a quarter of a million.



View showing Underside of Floor Carrying Tanks.

REINFORCED CONCRETE WORK AT THE IMPERIAL PAPER MILLS, GRAVESEND.

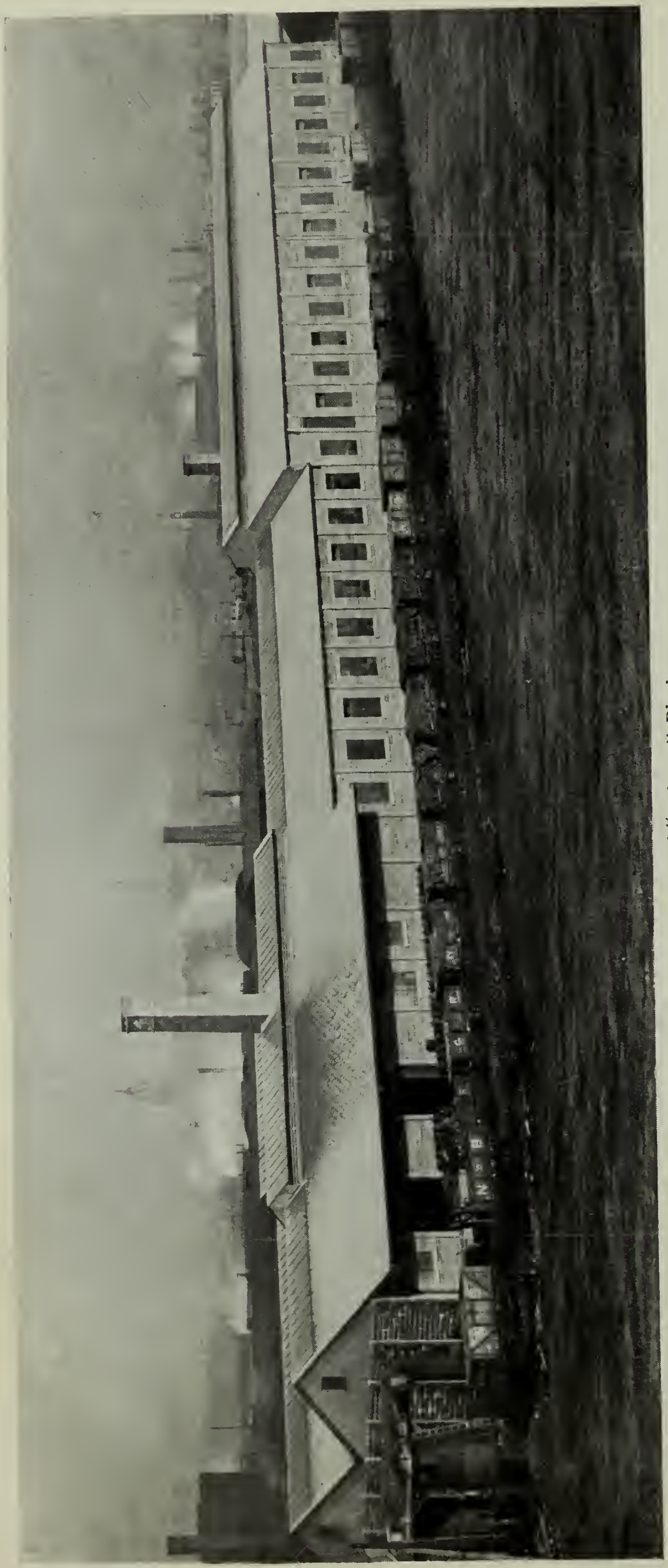
Our illustration on page 709 shows the reinforced concrete tanks in connection



View of Reinforced Concrete Tanks.

Reinforced Concrete Work at the Imperial Paper Mills, Gravesend.

with the mills. These tanks have a capacity of approximately 260,045 gals., the largest being 157 ft. 6 in. by 42 ft. 6 in.



Made of "Winget" Blocks.

Wire Mills, Lochrin Ironworks, Coatbridge.

The floors of the mills are of reinforced concrete supported by reinforced concrete columns. They support nine pulp-beating machines, and have been designed for a moving load of 5 cwt. per cu. ft., with a factor of safety of 4.

All the reinforced concrete work is on the Hennebique system. The general contractors for the work were Messrs. W. J. Fryer & Co., of Bravington Works, Paddington, W.

WIRE MILLS, LOCHRIN IRONWORKS, COATBRIDGE.

Messrs. Wm. Bain & Co.'s new wire mills, at Lochrin Iron-Works, Coatbridge, were erected with "Winget" concrete blocks.

The building is 600 ft. long, 82 ft. wide, and the walls of 4½ in. blocks—carried to a height of 16 ft. and 20 ft.—are reinforced at intervals in the horizontal joints with ribbon steel.

The roofs are carried on steel columns, which on an average are 12 ft. apart, and are built round with special shaped concrete blocks (also made on the "Winget" machine), so that the outside wall shows a continuous front of concrete blocks.

REINFORCED CONCRETE AT THE FESTIVAL OF EMPIRE AND IMPERIAL EXHIBITION.

Reinforced Concrete Staircases.

In the frontispiece to our July issue we showed an illustration of one of the reinforced concrete staircases erected at the Festival of Empire. The two staircases, which are similar, are L-shaped,

Reinforced Concrete Gallery at the Festival of Empire.

and lead down from the main floor level to the terrace below, a height of about 34 ft. 7 in., the upper limbs being 24 ft. $6\frac{1}{2}$ in. wide over balustrading, and about 75 ft. 8 in. long ; the bottom limbs being 21 ft. $4\frac{1}{2}$ in. wide and 77 ft. 4 in. long.

The steps are 14 in. by 6 in., with grooved treads, the whole of the upper surface of steps and landings being finished with 1-in. of granolithic, special care being taken to see that this was put on as soon as possible after the main body of concrete had been deposited.

The design, which allowed for a moving load of $1\frac{1}{2}$ cwt. per sq. ft. in addition to the dead load, involved some special consideration, and was made somewhat heavier than otherwise necessary, as it was essential that no shuttering should be left up after May 11th, and both flights had to be ready for use by May 12th, work having been commenced on February 10th. The short time in which the work was completed, and the excellent finish obtained, reflect great credit upon the contractors, The Empire Stone Co., Ltd., who carried out the work to the designs and under the supervision of Mr. Burnard Geen, A.M.I.C.E., Consulting Engineer to the Council of the Festival of Empire and Imperial Exhibition.

Reinforced Concrete Gallery.

Another structure at the Festival of Empire in which reinforced concrete was used is the reinforced concrete gallery, shown in the illustration on page 711. The building in which this gallery was constructed is a polygon, having 16 sides, the diameter being roughly 123 ft. 6 in.

In order to increase the available floor space, it was decided to construct a gallery 15 ft. wide round the entire building. Reinforced concrete was adopted, as not only did it cost some 15 per cent. less than a construction in steel girder work and concrete filling, but also gave a fire-resisting structure, which was an essential requirement, owing to the very valuable nature of the exhibits to be housed in the building. The 16 main columns were set out by dividing the inscribed circle of the building into 16 parts, the centres of the columns being at the intersection of the radii thus found and lines drawn parallel with the sides of the building, and 12 ft. out from the walls. The main beams are 16 in. by 7 in., the secondary beams being 9 in. by 5 in., with 3 ft. cantilevers, three out of four of which are arranged at right angles to the side walls, every fourth being arranged to radiate from the centre of the building.

The slab is $3\frac{1}{2}$ in. thick. Access is provided to the gallery by two staircases, the whole of the upper surface of the stairs and gallery being finished with 1 in. granolithic, put on as soon as possible after the main body of the concrete was deposited.

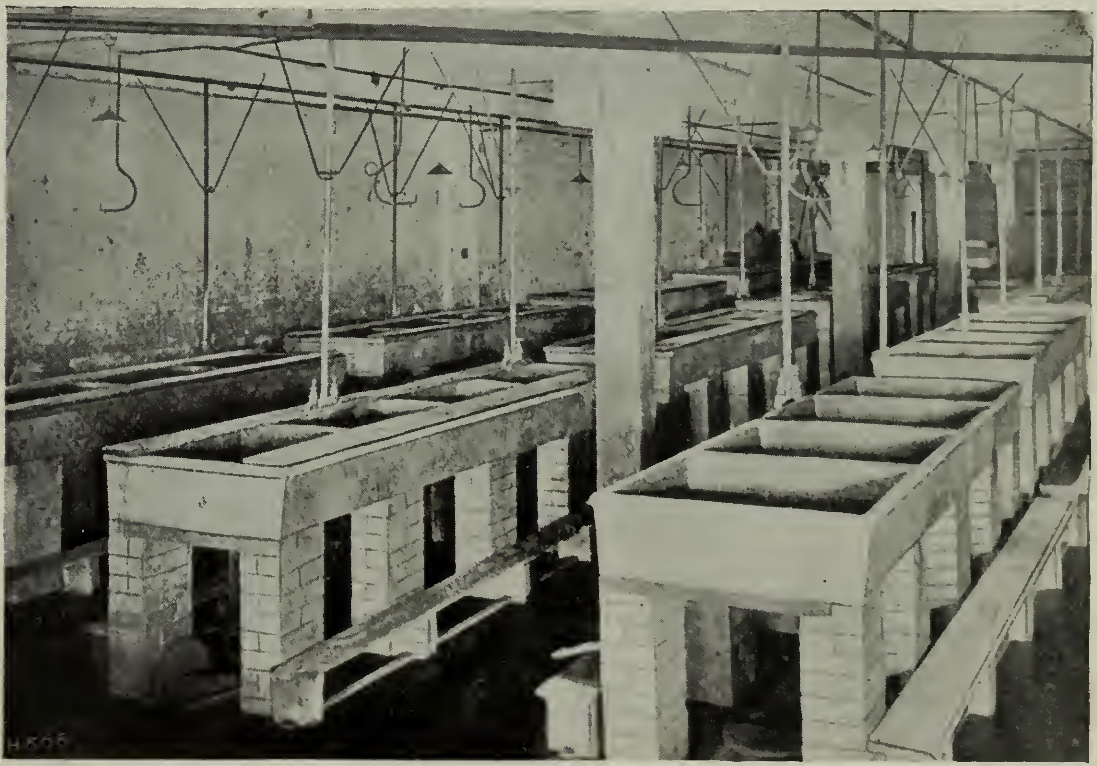
The design is of the plainest possible description, and everything was done to keep the cost down to a minimum. The work was designed to carry a safe load of $1\frac{1}{2}$ cwt. per super foot in addition to the dead weight, and was carried out by Messrs. Humphreys, Ltd., of Knightsbridge, to the designs and under the supervision of Mr. Burnard Geen, A.M.Inst.C.E.

NEW USES FOR CONCRETE
AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork where structures of great height are required.—ED.

CONCRETE FISH MARKET TROUGHS.

THE illustration below of the application of reinforced concrete in the construction of fish troughs is a striking example of the numerous different ways in which this material is used where hygienic conditions are of primary importance. The troughs in question are in the Fish Market in Sydney, New South Wales, and they have been highly satisfactory. Being poured monolithic, these troughs are quite sanitary and are easily cleaned, in addition to which the great inherent strength of this form of construction permits of reasonably hard usage without detrimental effect. These troughs have proved so satisfactory that concrete has been adopted for similar constructions in other parts of Australia. We are indebted to the *Cement World* for our illustration.



CONCRETE FISH MARKET TROUGHS IN SYDNEY, N.S.W.

CONCRETE DRINKING PLACE FOR CATTLE.

OWING to the great strides made in recent years for sanitary conditions for cattle, etc., on farms, the use of concrete for such purposes has rapidly increased, as it is generally recognised that there is no better method of securing absolute cleanliness. The durability and economy of this form of construction also commend themselves particularly to the farmer.

The concrete drinking place, illustrated on this page, was erected by Mr. Fred. Ballard on Winning's Model Dairy Farm, at Colwall, Malvern.

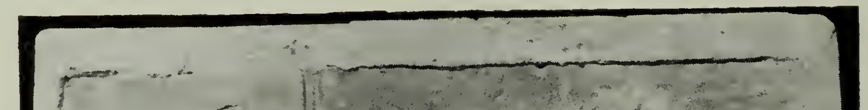
The method of construction was extremely easy, and consisted of cutting through an agricultural drain, a space of about 4 ft. wide being dished down slightly below the drain level, and the whole surface covered with concrete.

Concrete Drinking-place for Cattle.

Two posts and a beam on the top side of the drinking place prevent cattle falling in. The drain in question taps a small spring, seldom or never dry, and thus provides a clean supply of water instead of the usual dirty drinking place. The entire cost was under 20s.

CONCRETE IN THE GARDEN.

We are constantly presenting examples of the use of concrete in the garden. The work lends itself admirably to the amateur gardener who has time on his hands, and has a taste for carving or modelling. The illustration herewith shows a concrete garden ornament made at the School of Industrial Art of the Pennsylvania Museum.



Concrete Garden Ornament.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

Manual of Reinforced Concrete and Concrete Block Construction. By Charles F. Marsh, *M.Inst.C.E., etc.,* **and William Dunn,** *F.R.I.B.A.*

Published by Constable & Co., Ltd., 10 Orange Street, Leicester Square, W.C. Second edition. 7/6 net. x.-312 pp.

Contents.—Part I., Materials ; Part II., Construction ; Part III., Waterproofing and Fire Resistance ; Part IV., Loads, Bending Moments, etc. ; Part V., Calculations ; Part VI., Hollow Concrete Blocks ; Part VII., Tables, Diagrams, and General Information.

The little "manual" of Messrs. C. F. Marsh and William Dunn, based in the main on the larger work by the same authors, has now reached a second edition, and has undergone some revision as well as enlargement by the addition of a series of appendices. The little book has proved its value in actual use, and is probably already familiar to most persons engaged in the practice of reinforced concrete construction. It is strongest on the engineering side, the methods of computing stresses, bending moments, etc., in structures of very diverse kinds, being treated with great fulness, with an extensive use of graphical methods. In this connection the criticism may be made that some of the diagrams have suffered badly by reduction to the size of the small page, so that the detail becomes blurred, making the reading of the figures difficult, even with the aid of a glass. For this defect the authors are, of course, not responsible, but the convenience of these graphical diagrams is such that the point deserves attention. All who have to deal with the transformation of metric into British units will appreciate the advantage that such diagrams as *Figs.* 106 to 111 possess over tables, but the practical engineer would probably prefer to re-draw them on a larger scale.

The numerous fully-worked examples of calculation are of great value. The working stresses assumed throughout are : 600 lb./in.^{2} for concrete in compression in beams, and 16,000 lb./in.^{2} for steel in tension, these being the figures assumed as normal by the Committee on Reinforced Concrete of the Royal Institute of British Architects. An examination of the worked examples should, however, make it easy to substitute the values when these seem to be justified by the results of tests of the concrete. The difficult subject of the pressure of earth on retaining walls is well treated, this section including a summary of the discussion on the subject in the American Society of Civil Engineers in 1907, from which it is evident that the theory of earth pressure in such cases is still very imperfect, in spite of the great amount of practical experience already available. The question of pressure on the bottoms of hopper bins and silos is treated briefly, but clearly. Slabs and T-beams are fully treated, and an appendix contains the article on the graphical statics of reinforced concrete structures contributed to *Engineering* by Mr. Dunn in 1908. Other appendices deal with the calculation of an arched roof truss, with the spacing of stirrups, and with the reinforcement of hooped columns. The book also contains a number of tables of engineering data.

The principal criticism to be made relates to the first three chapters, in which the materials of construction are discussed. The quality and preparation of the concrete, on which the strength and durability of the structure depend so entirely, deserve fuller treatment than they receive, especially as regards the proportioning of the ingredients in order to obtain a minimum of voids in the concrete. A few data are given in a later part of the book, under the heading of hollow concrete blocks, but further information of the kind to be found in several continental manuals would have been very useful. A number of recipes for mixtures intended to render concrete waterproof are given, but the addition of petroleum to the concrete during mixing, recently practised in America with good results, is not mentioned, and the necessity for such artifices would be almost, if not completely, obviated by greater attention to the scientific grading of sand and aggregate, so as to obtain a thoroughly dense and impermeable concrete without the addition of extraneous substances, which frequently impair its strength. The notes on fire resistance are clear and adequate, although greater emphasis might have been laid on the necessity of special precautions to ensure that reinforcing rods are always situated at a sufficient distance from the surface. The effect of variations of temperature in producing stresses in reinforced concrete structures is discussed on page 202, these stresses being of much less importance than has sometimes been assumed. The authors' allowance of 15° as the range of temperature to be taken into account is probably ample.

Special forms of reinforcement are described and illustrated, but the selection appears to be somewhat arbitrary, and this section might well be revised. The account of the manufacture of hollow concrete blocks is compiled from the *Cement Age*, and other forms of construction, more familiar in this country, are omitted. There are several misprints of proper names.

It has been thought advisable to select those features of the book which are open to criticism, in view of the probability that a further edition will be called for before long, when certain emendations might be made with advantage. Nothing, however, that has been said as to minor blemishes detracts from the great value of the " manual " for practical men and students. Its compilation has involved a vast amount of labour, and could only have been undertaken by men with a thorough knowledge of their subject. The authors are to be congratulated on their work, for which their readers should be grateful.

" Lectures on Reinforced Concrete delivered at the Institution of Civil Engineers in November, 1910." By William Dunn, *F.R.I.B.A.*

Published by University of London Press, Hodder & Stoughton, Warwick Square, E C. Price 7/6. 8vo. 142 pp.+vii. diagrams.

Contents.—Columns and Compression Members—Beams—Retaining Walls—Bridges—Quantities and Costs—Failures—Appendix I.: Graphical Solution of the Continuous Girder—Appendix II.: Diagrams for the Solution of T-beams.

It is an excellent feature of the reorganised University of London that provision is made for the delivery from time to time of special courses of advanced lectures, unconnected with examinations, by lecturers distinguished in their respective subjects, and not necessarily members of the academic staff. Mr. Dunn's lectures on reinforced concrete, delivered last year to advanced students of engineering and others, are a result of this scheme, and have now been reprinted, with a few additions, by the University of London Press, forming a handsome and excellently printed volume.

It may be assumed that the lecturer had in view those members of his audience who already possessed a knowledge of general engineering, but who had no experience in, or special knowledge of, reinforced concrete construction. The six lectures deal, respectively, with columns and compression members, beams, retaining walls, bridges, quantities and costs, and failures. An appendix contains the graphical solution of continuous girders, treated in detail, by a method which has been chiefly employed on the continent. A set of seven diagrams for the solution of T-beams with single and double reinforcement has also been added, and the folded drawings are enclosed in a pocket at the end of the book. These diagrams, which should prove of great value to designers of reinforced concrete structures, have been reprinted on thick paper and are obtainable separately.

The lectures should serve a useful purpose in directing attention to the advantages of construction in reinforced concrete, especially as the author does not adopt an attitude of undiscriminating enthusiasm, but argues fairly and with judgment. This is particularly noticeable in the chapter on costs, in which the author rejects the claim, sometimes made, that reinforced concrete is always the cheapest material, and bases its claims rather on its permanence and resistance to fire. These advantages certainly justify the increased expenditure which is often involved in the adoption of reinforced concrete in the place of unprotected, or imperfectly protected, steel construction. The chapter on failures, although expressed only in general terms, contains useful warnings and is very suggestive. It is highly desirable that students should give careful consideration to recorded cases of failure and to the special dangers which present themselves in this type of construction when necessary precautions are omitted either from rashness or, as more frequently occurs, from lack of proper supervision during erection.

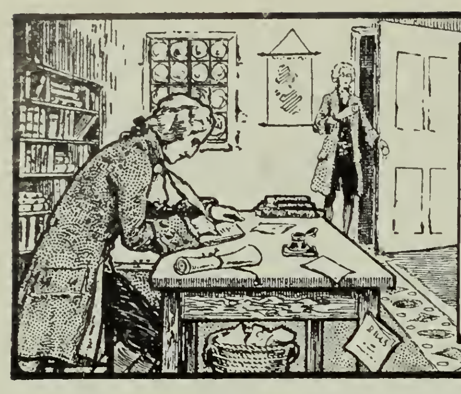
The remaining lectures do not, of course, cover the field of construction in reinforced concrete, but treat only of certain selected aspects of the question. Reference is made to the existence of patented systems, and examples are occasionally taken from certain of them for purposes of illustration, but it is rightly pointed out that although the use of special patented reinforcing bars may sometimes be of advantage, the general method of construction, using plain steel bars, is independent of special " systems."

The introductory section, dealing with the composition and mixing of the concrete, is the least satisfactory part of the book, the information given being too scanty to be of much practical value. This being a subject of which the ordinary student of engineering has little or no knowledge, more attention might with great advantage have been given to it. It is in the direction of more accurate grading, proportioning and mixing of concrete that the greatest increases of strength, durability and resistance to destructive agents are to be sought. In discussing the action of sea water on concrete in marine works, a short abstract is given of the admirable experiments of the Scandinavian Portland Cement Manufacturers, which led unmistakably to the conclusion that, at least in northern latitudes, the direct chemical action of sea water is insignificant in comparison with that of mechanical erosion, evaporation and frost.

In the calculations, the ratio of the moduli of elasticity is assumed throughout to be 15, although it is admitted that the true ratio is very variable on account of the variation of the elasticity of concrete with its composition, age, and degree of compactness. It is, of course, desirable to use a more accurate value when the necessary data are available in the form of tests of the concrete. The principle of the conservation of plane sections is also assumed, and, whatever theoretical objections may be advanced against such a procedure, it is certain that it is unavoidable in ordinary routine work.

Retaining walls, dams, and bridges are next discussed, the treatment of retaining walls being fully mathematical whilst that of bridges is more general. Some consideration is given to the question of æsthetic treatment, the author urging that the appearance of reinforced work must depend chiefly on the structural form, and only in a lesser degree on colour and texture. This is a point which should be borne in mind by designers of reinforced concrete structures. The author objects, in our opinion rightly, to bowstring girder bridges and similar mere imitations of steel structures in reinforced concrete. The acid treatment of concrete is recommended for the production of a pleasing surface.

The only criticism to be made of these lectures is that they exhibit a certain inequality of treatment, some sections being comparatively advanced in character, whilst others are very elementary and general. A systematic review of the subject was neither to be looked for or desired, and the inequality alluded to was no doubt difficult to avoid. Differences of opinion will exist as to the hypotheses adopted in certain cases, but this is true of the whole subject, which is far from having reached a stage in which there is general agreement as to its theoretical foundations. Mr. Dunn's book will fulfil its purpose of arousing the interest of young engineers in this mode of construction, and so indirectly assist in the establishment of that better scientific basis which is so desirable.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Instruction in Reinforced Concrete and Structural Engineering.—The session for the course of instruction in reinforced concrete at the London County Council's School of Building, Ferndale Road, Brixton, opens on September 18th, the lecturer being Mr. H. Kempton Dyson, the Secretary of the Concrete Institute. The full scheme of instruction is as follows :—

Elementary Course : (1) Reinforced Concrete Construction, Quantities and Practical Work—Mondays. (2) Reinforced Concrete, Theory and Design—Tuesdays. (3) Drawing and Design of the Constructonal Steelwork of Buildings—Wednesdays.

Advanced Course : (1) Structural Design—Wednesdays. (2) Reinforced Concrete, Theory and Design—Tuesdays. (3) Drawing and Design of Reinforced Concrete and Steelwork—Fridays.

The time will be 7–9 p.m. and the Session lasts about 30 weeks. The detailed syllabus can be obtained free on application at the School. The fees are very moderate, being 10s. per session (and in special cases 4s. 6d.).

Coast Erosion.—The final report of the Royal Commission on Coast Erosion has just been published. Part I. deals with the physiographical and geographical considerations affecting the coast line. Part II. treats of the extent of erosion in recent years on the coasts and in the tidal rivers of the United Kingdom. Part III., which will be of most interest to our readers, deals with sea protection works and gives evidence of various witnesses as to the design of sea-walls, groynes, etc. In this respect the following conclusions of the Committee are worthy of note :—

> With regard to sea-walls and similar works of defence, for the reasons we have given, their construction should almost invariably be accompanied by suitably designed groynes, extending seawards continuously from the face of such works and carried out simultaneously therewith.
>
> With respect to groynes, speaking generally, our view is that, to be of maximum efficiency, they should be of a distance apart about equal to their length ; that they should extend continuously from the shore or work to be protected to the vicinity of low water of spring tides ; and that, with regard to direction, they should point slightly to windward. With respect to their height, this must be governed almost entirely by local conditions and requirements.

The report is accompanied by three plates showing the plan and sections of various groynes in England, and three showing the design of different sea defence works in Holland.

Soap Water in Concrete.—Soap water in concrete has, it is said, been used in Germany, instead of ordinary water, to make reinforced concrete water-tight. A grain elevator, which was exposed to inundation, was built on the Danube, the gauging water used for the concrete being replaced by a solution of potash soap. The building has stood one inundation well, while another building of the same material, without the soap, did not keep out the water completely.

More than a Mile of Concrete Floor.—The recently-completed Armour-Swift-Burlington Bridge crossing the Missouri River at Kansas City, U.S.A., is 5,998 ft.

long, and the entire floor is of concrete, mixed in a single Ransome mixer, which was located on the shore directly under the bridge, the material being hoisted in a tower. This is probably the longest concrete floor in the world.

Tests on a "D. G. Somerville" Floor.—Messrs. D. G. Somerville & Co. send us the following account of a test of one of their fire- and sound-resisting floors which was recently carried out by them at their New Cross works, under the supervision of the Metropolitan engineer, Mr. Drury. Messrs. Somerville's floor consists of hollow reinforced concrete tiles of about 3 ft. 4 in. span, of an arched section, the reinforcing consisting of a network of steel rods, being continuous round the tile. The tiles are manufactured in iron moulds, and are then matured for two months before being used.

The test was carried out with a view of testing the load-carrying capacity, and also as to whether there was any thrust transmitted by the arched tiles to the R.S. joists when heavily loaded. A section of floor, 7 ft. span by 3 ft. 4 in. wide, was constructed with two 6 in. by 3 in. R.S. joists, six tiles being placed between them, and then concreted over with clinker concrete, gauged six and one. The age of the tiles was three months, and of the finished floor five weeks, the two 6 in. by 3 in. R.S. joists being tied together by three ¾ in. diam. tie bolts, to take up any thrust. Messrs. Somerville guarantee this floor to support a superimposed load of 3 cwts., but under a concentrated load of 7 cwts., equivalent to a distributed load of 14 cwts., no deflection or sign of failure could be observed, the loading at this point having to be discontinued owing to the impossibility of carrying it up any higher.

Test of "D. G. S." Patent Floor for the Metropolitan District Railway.

When a load of 10 cwts.—or half a ton per sq. ft.—was reached, the tie bolts were unscrewed, but not the slightest sign of thrust could be observed, even when the maximum load of 14 cwts. per sq. ft. was reached, this clearly proving that the bottom cord was a perfectly efficient tie.

The illustration shows the general arrangement of the test.

It is interesting to note that this system of flooring has proved to be most effective in railway cuttings, as a preventive of the noise of the trains, and has been extensively used for the purpose.

Railway Sleepers of Reinforced Concrete and Asbestos.—A new reinforced concrete railway sleeper tested on the Bavarian railways seems to combine the elasticity of wood with the durability of steel and concrete. Asbestos fibres soaked in water and saturated with pure cement is one of the elements used. The

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mixture, after complete saturation with water, forms a soft, tenacious mass which does not permit tamping or ramming as concrete does, but reaches two-thirds of the breaking strength of concrete. After setting it can be drilled, nailed and hammered like wood, and retains its hold upon other materials better than wood. The concrete consists of one part cement, one part rubble, and two parts gravel sand. The asbestos is used only below the actual seat of the rails.

The seven steel rods of the tensile zone reinforcement are imbedded below the rail seat, which is also of concrete, and the asbestos is placed on top of this. This lessens the cost of the tie, as the asbestos is rather expensive. A tie costs about 6s. 3d. The weight is about three times that of the wooden tie, 220 kg. (484 lbs.) The setting of the cement and asbestos is much slower than that of concrete, and is accompanied by formation of heat. Hydrates of lime are formed in the process, as asbestos (calcium-magnesium silicate) has only a little silicic acid due to impurities. The excess of lime in the cement (25 per cent.) is also changed to hydrate of lime with formation of heat. Whether the ties will meet the requirements of the expected wear and tear is still a matter of doubt, as they have only been used five months so far, although they have shown no defects within this time.—*Zement and Beton.*

TRADE NOTICES.

A New Reinforced Concrete Firm.—Messrs. Trollope & Colls, of London, the well-known firm of contractors, have added an engineering department to their company for design and construction of structures in reinforced concrete or steelwork.

The offices of this department are at 5 Coleman Street, London, E.C.

The British Reinforced Concrete Engineering Co., Ltd., inform us that their new handbook is in the hands of the printers at the present moment and will be ready for issue early in September. This will be sent on application to the Company's office at 196 Deansgate, Manchester.

The British Concrete-Steel Company has now been merged in the Indented Bar and Concrete Engineering Co., Ltd., Queen Anne's Chambers, London, S.W., and their northern agent is Mr. W. R. Taylor, 50 Brudenell Mount, Hyde Park, Leeds, to whom all communications should be addressed.

W. Love's System of Flat Sheet Rolling.—An interesting pamphlet has been sent us by Mr. Love regarding his new invention for obtaining uniform flat sheets and thus eliminating deflection in rolling machinery.

In order to obtain perfectly flat sheets it is essential that the rollers used for these sheets should not bend or deflect. However, the great majority of pressure rollers as at present constructed are supported by their bearings at the two ends, and have no intermediate support, so it follows that such rollers will bend when in use. The principle of Mr. Love's system consists in supporting the pressure rollers at intermediate points along the length by means of bearings, leaving the ends free. Mr. Love's system consists in providing means for suitably distributing the pressure on the bearings supporting the pressure roll, which is essential to produce uniform pressure along the working surface of the roller.

Among the other advantages claimed for this system are that rollers even of small diameter remain perfectly parallel under every load, and that accuracy of flat rolling is quite unaffected by variations of pressure, speed, or hardness of material. There is also economy of driving power and of first cost and renewals.

This invention was submitted to Mr. W. Dudell, M.I.E.E., F.R.S., who says at the conclusion of his report that he considers the principle of Mr. Lowe's system scientifically sound, and that the application of this principle properly carried out showed result either in a considerable improvement in the straightness of the roll under all loads or in the possibility of using a very much lighter and thinner roll for the same work.

For fuller particulars of the system we must refer our readers to the booklet and the literature on the subject, which are obtainable from Mr. Love, 42 Claremont Square, N.

Messrs. Edmond Coignet, Ltd., have recently issued a very excellent booklet on their system, with notable examples of work executed in this country. This booklet is published in large quarto size, and comprises 122 pages of well-illustrated matter and should be of great interest to all architects and engineers concerned in the design and execution of reinforced concrete work, as it shows the adaptability of the Coignet system to many different classes of work, including not only large factories and office buildings, wharves, piers, and bridges, etc., but also water reservoirs and tanks, coal bunkers, silos, and many other similar structures. Besides the British examples, a few others are presented from distant lands, notably the extensive public buildings in Jamaica, which have been described in this Journal.

Reinforcement of Columns.—In the article on the second report of the Joint Committee of the R.I.B.A. in our August number we quoted a paragraph from the report which states, concerning the construction of pillars under direct thrust, that "The most efficient disposition of the lateral reinforcement would appear to be in the form of a cylindrical helix." Messrs. The Considère Construction Co. inform us in this connection that the circular hoops and cylindrical helix, when used for reinforcement, are covered by the Considere patent, which is controlled by them.

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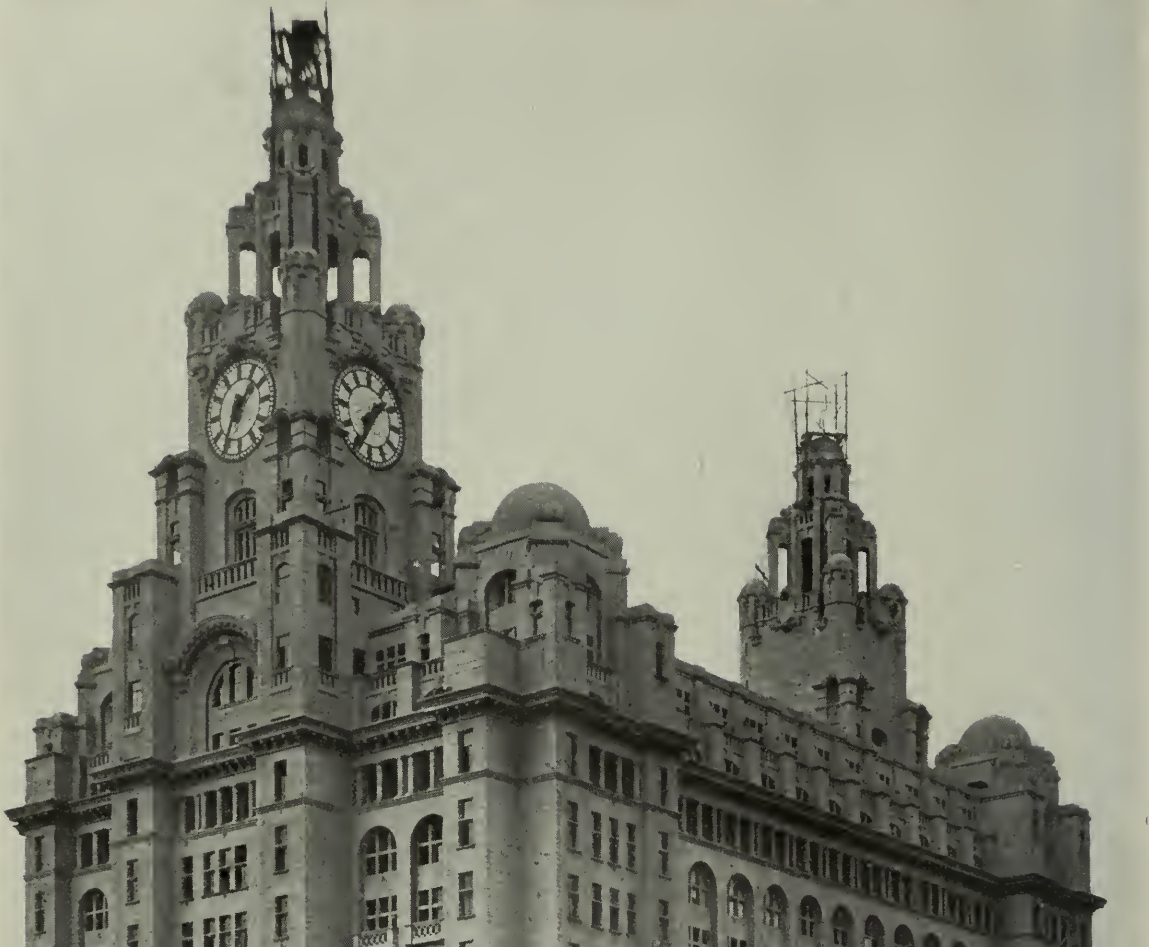


(*Frontispiece*)

View of Finished Structure.

THE ROYAL LIVER BUILDING, LIVERPOOL.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume VI. No. 10. LONDON, OCTOBER, 1911.

EDITORIAL NOTES.

THE REINFORCED CONCRETE TRADE.

IT is with much regret that we have heard numerous complaints during the current year from the reinforced concrete trade that, in their efforts to create a great industry, the profits as a rule are so diminutive, and that it is impossible to speak of the trade as a prosperous one as a whole.

This appears to be particularly the case where firms combine the duties of designers and contractors, as distinct from those who are designers pure and simple, and draw fees as designers from contractors by way of commission on the value of the work done under their special systems. To put it plainly, the firm that acts both as designers and contractors seems to fare worse than the firm that acts as specialists and designers only. Further, the firm that acts as contractors in a general way, and looks upon reinforced concrete structures purely as buildings executed in the ordinary course of their business, much as they would look upon a steel frame building, or a temporary wooden structure, appears often to fare better with reinforced concrete than a newly-established firm that lays itself out to do reinforced concrete work *only*.

We have before us particulars of several well-known firms who have lately found it necessary to retire from the reinforced concrete trade, and who belong to the category of establishments who did both their own designing and contracting. We have long argued that this combined form of doing business is anomalous and not in the interest of reinforced concrete. We have strongly held that specialist designers, much as specialist consulting engineers, have a *raison d'être*, and whether they be paid by their clients or by contractors on royalty is of little matter as long as the fact of the payment being made is clearly understood by the employer.

We have also strongly held that existing experienced contracting firms who take up reinforced concrete as an additional department are likely to work the material to make it pay best. One of the advantages of having a reinforced concrete department as an adjunct in a general contracting business is that the work of the department may fluctuate in amount without materially affecting the general turnover of the general business. Fluctuations in a business devoted to reinforced concrete only are very serious matters. If the general contractor should give his reinforced concrete department a staff for general designing, much as he is prepared to design or obtain designs for any piece of steel frame construction, or for any decorative scheme, all well and good, and as long as the demands made upon him for these are not out of the ordinary, he will no doubt be able to handle a proposed scheme of reinforced concrete construction that is put before him for design much as he is able to deal with any ordinary proposal for a steel frame design ; but should the problem put before him be a difficult one, he will be well advised to call in a specialist consultant to help him, much as he would ask a consulting engineer to help him get out his design for a complicated piece of steel frame work.

Reinforced concrete lends itself particularly as a department of a big contracting firm, for then the contractor can erect uprights and floors in reinforced concrete, fill in brick walls, put in the joinery, etc., all under one contract, or undertake the reinforced concrete work pure and simple as the case may be. The firm that undertakes reinforced concrete only is, on the other hand, generally not equipped to undertake other work.

The firm that sets out to do reinforced concrete work only—to do the designing and the contracting combined—sets out under particularly difficult circumstances, and unless it enjoys considerable financial strength and influence, it is more likely to fail than to succeed. The reason for this is, in the first place, that the demand for reinforced concrete buildings fluctuates considerably, and whilst such a firm may be busy, indeed, for one year or for one season, employing a large designing and executive staff, it may find itself the next year very slack indeed, with its staff idle.

The responsibility of reinforced concrete contracting is also considerable. Money has to be left as retention money for long periods. On the other hand, the credit given to the newer firms is short. But, above all, there is not enough work in reinforced concrete to feed the many general contractors, who would scarcely feel an occasional slackness, and at the same time to provide a large number of specialist contractors with orders to whom reinforced concrete is their all in all.

Under the circumstances, we would warn *new* firms from establishing themselves solely as reinforced concrete contracting and designing specialists ; whilst, on the other hand, we would strongly recommend our large builders to follow the excellent example of firms like Messrs. Cubitt, Messrs. Trollope & Colls, Messrs. Stuart's Granolithic Co., and others, and not shut their eyes to the advantages of a reinforced concrete department.

As to the specialists occupied purely with design, those who exist, be they individuals or limited companies, will no doubt have a fair future, more particularly if they do not limit themselves to designing solely on the systems with which their names are associated, and will take up the position of general consultants ready to design anything in any form of reinforced concrete that the employer may demand.

We are fully aware of the complaints of those who have now closed down their businesses, and also of others, that one of the causes of failure to make reinforced concrete remunerative in the form of combined specialist and contractor is due largely to causes over which they have no control—namely, the insensate undercutting in prices of certain firms who seem to regard a bulky unprofitable turnover of more importance than a smaller profitable one ; and, secondly, owing to the great hardship inflicted upon firms of this kind in having to put in elaborate designs and detailed quantities for employers and architects on the off-chance of their getting an order.

Into the problem of undercutting, we may enter on a future occasion. Regarding the question of the architect who demands detailed designs from competitors, we have already expressed our opinion forcibly ; but here, again, we may take up the matter on a future occasion. In the meantime, we trust that in the coming session of the Concrete Institute that body may do something tangible to ameliorate this last named feature which has become an absolute nuisance to a very deserving pioneer industry.

THE JOINT COMMITTEE'S REPORT.

In criticising the Report of the Joint Committee on Reinforced Concrete in our September issue we dealt with the subject of formulæ for the calculation of the strength of hooped pillars. Our remarks were, however, framed on a misreading of the report in one particular—namely, in respect to the symbol r, which we find refers to the volumes of hooping and the core, and not to the hooping and the longitudinals. The result is that the spacing factor is a single term, and the formula is quite rational, so that we find ourselves in theoretical agreement therewith.

The limitation of stress on the concrete also then becomes a reasonable precaution, as it means that a limit—expressed in terms of the ultimate resistance of a cube of plain concrete—is imposed to prevent escape of the materials between the spirals by a somewhat analogous action to the fluidity of metals when they pass their elastic limit.

As we have said before, we are sorry that the Committee did not explain their recommendations in detail, because, as the above is an instance, we have found it easy to misapprehend the purport of any ruling when one has to do a lot of expert reasoning to find out the meaning. Perhaps the idea is that of the old judge who told the young one " Give your conclusions, but never your reasons, for your conclusions may be right though your reasons be wrong." That, however, is not the scientific and helpful spirit we would like to see in vogue.

THE CONCRETE INSTITUTE'S NEW SESSION.

The new session of the Concrete Institute will shortly be starting, and we take this opportunity of reminding those in authority that a very large amount of useful work is expected from that body during the impending session, whilst at the same time papers are desired of higher average and greater technical interest than those presented during the past year.

The Institute on this new session starts with the material addition of new blood in its council, also with the new chairman to its important Science Committee.

No programme of the papers for the coming session has as yet reached us, and the problems that will be under discussion can only be arrived at by deduction, inasmuch as we know that the reinforced concrete regulations of the London

County Council will shortly be coming before the Local Government Board, and that the Institute's work on the standardisation of drawings, and on certain questions of tests, have not yet been completed.

The non-publication of a programme of papers is regrettable, seeing that in these busy times those members of the Institute whose influence in discussion is the most important, have to book up their appointments long in advance, and we have before us practically an excellent programme of the papers of nearly all the kindred societies.

The Concrete Institute is largely interested in reinforced concrete, and we think we should remind its council that a great deal is required at the present moment to assist that material in obtaining that recognised position among the structural materials that cannot be strictly accorded it as long as a Government department of such importance as the Local Government Board does not seem to recognise it to be of equal value to ordinary structural material.

It should be the business of the Concrete Institute to see that they are recognised during the impending session in all matters relating to concrete, and no time, effort or expense should be spared to push the matter forward.

TESTING REINFORCED CONCRETE BEAMS.

In this issue we are presenting particulars regarding the practical testing of reinforced concrete beams on Dr. Von Emperger's system.

We think the system put forward requires attention and that the possibility of obtaining simple reliable tests on the job is of such importance that Dr. Von Emperger's proposals should be carefully inquired into in this country, either for the purpose of development or for an adaptation to our purposes. The primary feature in the proposed test is simplicity, and at the present moment we certainly lack means for simply and rapidly testing reinforced concrete beams.

THE ROYAL LIVER BUILDING, LIVERPOOL.

The Royal Liver Building described below is one of the most important structures erected in reinforced concrete in this country, and the following description of the constructional work should be of great interest to our readers.—ED.

By ALBERT LAKEMAN.

THE adoption of reinforced concrete as the constructional material in this building must be considered as a very important fact, and one which affords conclusive evidence of the value of such material in cases where heavy loads have to be carried with a minimum number of supports, combined with efficient construction, fire resisting in character, and capable of rapid execution.

It is practically the first "skyscraper" in this country, and it must be considered as the finest example of a building in reinforced concrete that we

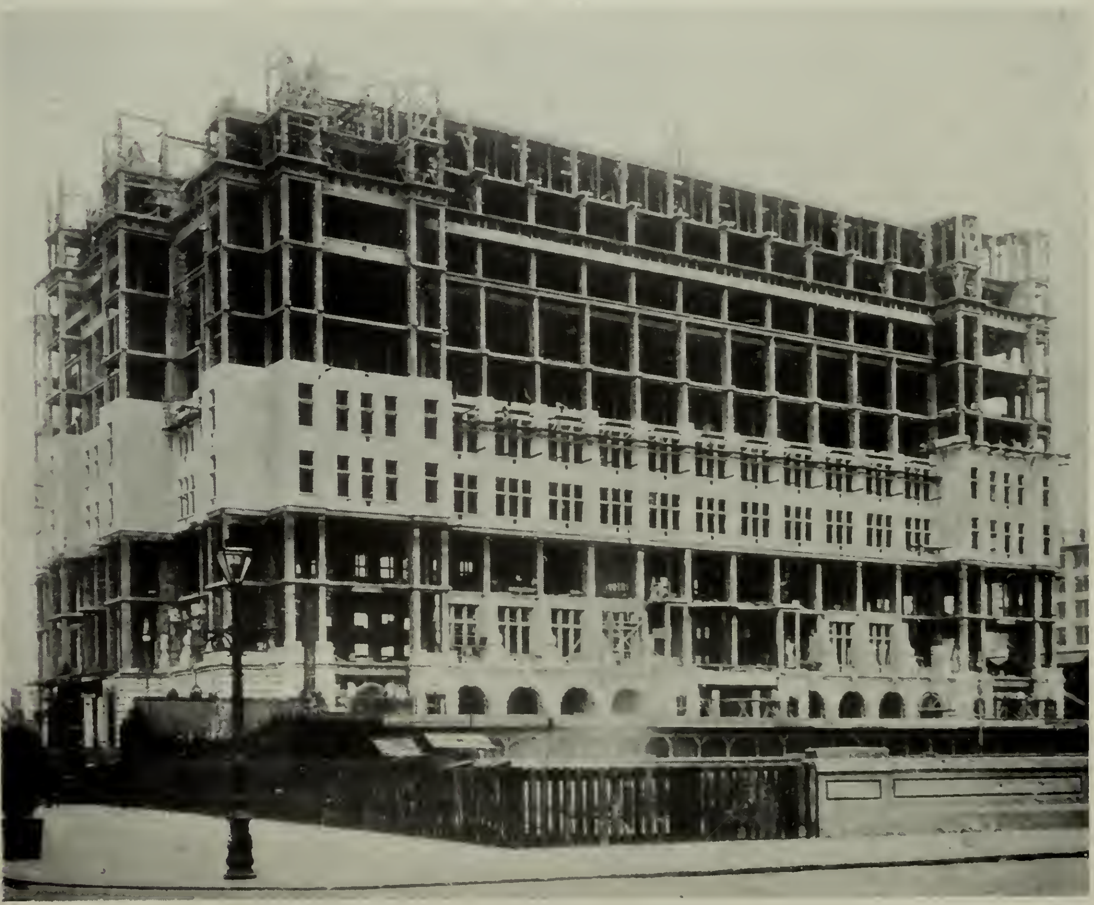


Fig. 1. View of Skeleton Construction.
THE ROYAL LIVER BUILDING, LIVERPOOL.

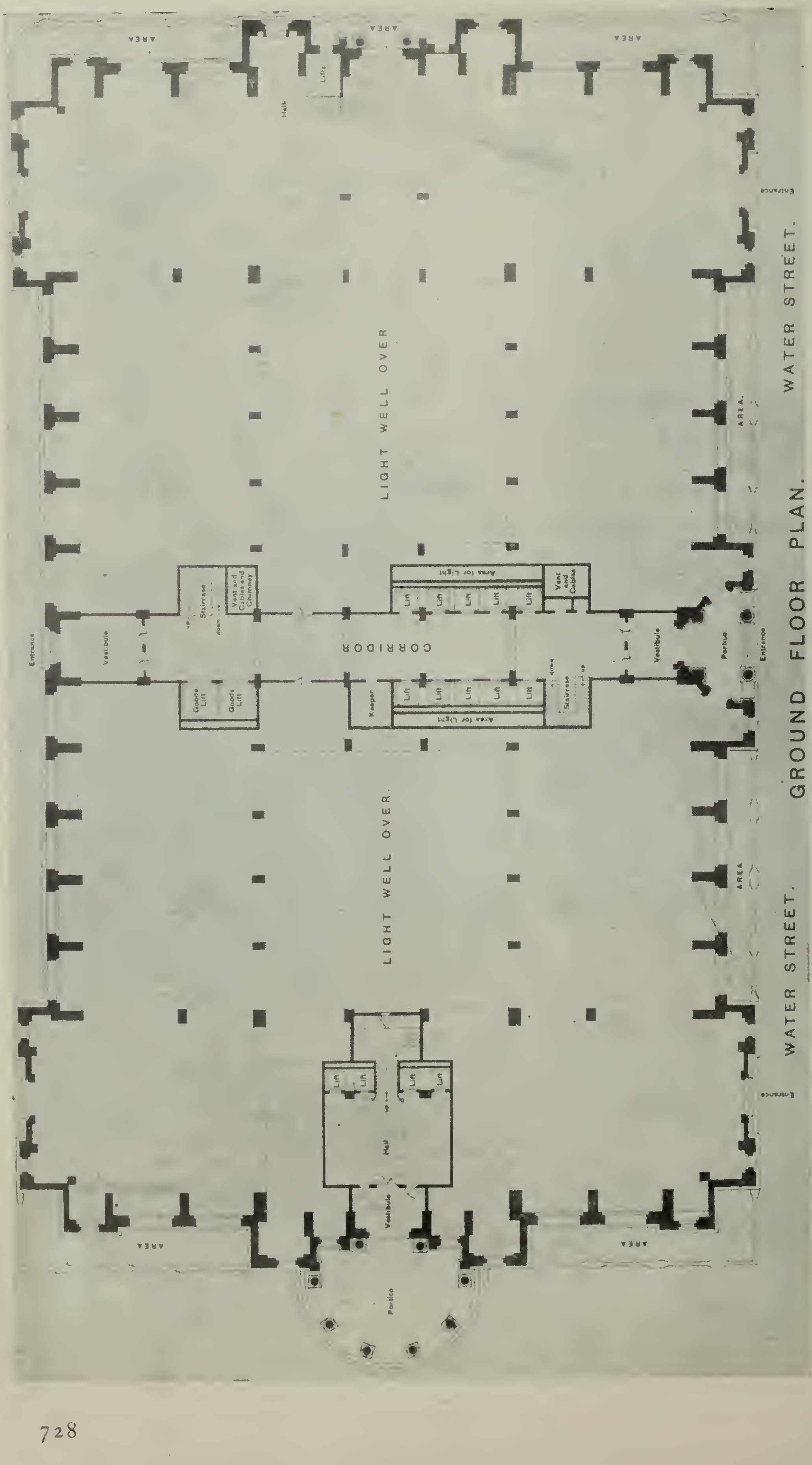


Fig. 2. Ground Floor Plan.
The Royal Liver Building Liverpool

have yet produced. Much discussion has taken place at different times as to the relative advantages of reinforced concrete and structural steel when rapid execution is required, and it is very interesting to note that in this building, which covers an area of about 45,000 sq. ft., the first seven floors were constructed in an average time of nineteen working days per floor, and this will commend itself to all those interested in the question of quick construction, which has become such an important factor in modern work.

The building, which has recently been opened, was designed as offices for the Royal Liver Friendly Society by Mr. W. Aubrey Thomas, of Liverpool, and the reinforced concrete work has been carried out on the Hennebique system, designed by Messrs. Mouchel & Partners. The site is that formerly occupied by the St. George's Dock, in the vicinity of Prince's Landing Stage, and the building measures about 301 ft. long by 177 ft. 6 in. wide, whilst the height up to the main roof is over 170 ft.

The domes of the two main towers are 295 ft. above pavement level, and there are eleven stories below the main roof, whilst each of the main towers contains six stories, making seventeen stories in all, and giving a total height of 320 ft. from the basement floor level to the top of the towers. These figures give some idea of the magnitude of the undertaking, and make it clear that enormous loads had to be carried by the foundations and lower columns. Owing to the soil being incapable of carrying these loads, it was necessary to sink concrete foundation piers down to the old red sandstone, lying at a depth of from 32 ft. to 47 ft. below the surface level, and these were connected at the top by reinforced concrete slabs upon which the loads were distributed. This foundation slab is surrounded by retaining walls constructed around the whole site, these being carried on large concrete beams formed between the foundation piers, which were at an average distance of 30 ft. apart. In some cases where piers were not available as supports, cantilevers projecting 11 ft. from the main columns were constructed to carry the retaining wall and basement flooring. The retaining walls themselves really act as deep beams, and were comparatively light in character, being formed with a 5-in. vertical slab, having a continuous coping 18 in. wide and 8 in. deep at the top, and an extended base consisting of a wide toe and slightly projecting heel. The slab itself is stiffened with vertical counterforts at short intervals apart, and horizontal ribs projecting from the slab and connected with the counterforts. This work was attended with great difficulty, and required to be executed with great care, as the subsoil water level rises to a height of 10 ft. above the basement floor line, and should any defect occur it would have very serious effects.

The ground floor plan is illustrated in *Fig.* 2, and the positions of the supporting columns can be seen, and it will be noticed that the number is comparatively small, thus giving an open floor space capable of being divided up in almost any manner required by the occupiers. These columns provide some interesting construction, the interior ones beneath the main towers carrying a total load of 1,200 tons each at the foundation level, while the corresponding members on the exterior wall support a total load of 1,500 tons each. These latter are 8 ft. by 3 ft., and are reinforced by 42 vertical bars, tied in every direction by $\frac{1}{4}$-in. diameter steel links spaced at 3-in. centres. These columns actually carry a load of 900 tons at the ninth floor level, and at this point they are only 3 ft. square. The remaining columns in the exterior walls which support floor loads and the granite curtain walls carry a total load of about 750 tons each at the foundation level, where they are 8 ft. by 1 ft. 9 in., while the average size at the top is 14 in. by 12 in.

Fig. 3. An Interior View.
THE ROYAL LIVER BUILDING, LIVERPOOL.

The beams and wall lintels provide examples of scientific design only possible with the material employed, owing to the heavy loads and large spans which had to be dealt with. All the columns are braced in every direction by the beams and lintels at each floor level, the latter being generally about 18 in. deep and

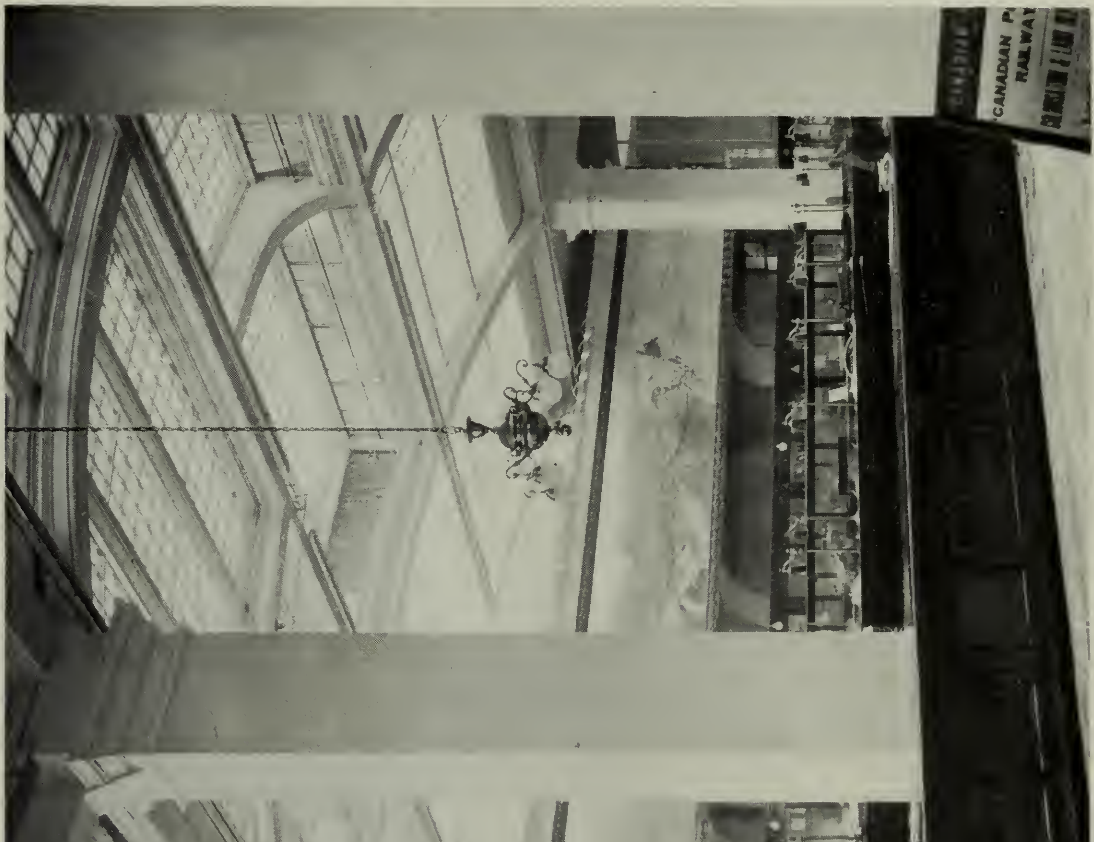


Fig. 4. An Interior View, showing concrete beams and arched ribs carrying glass roof.

The Royal Liver Building, Liverpool.

9 in. wide, reinforced with two bars in both the tension and compression areas. A typical floor beam has a span of about 40 ft., with a width of 9 in., and a depth of 34 in., including the thickness of the floor slab. The reinforcement consists

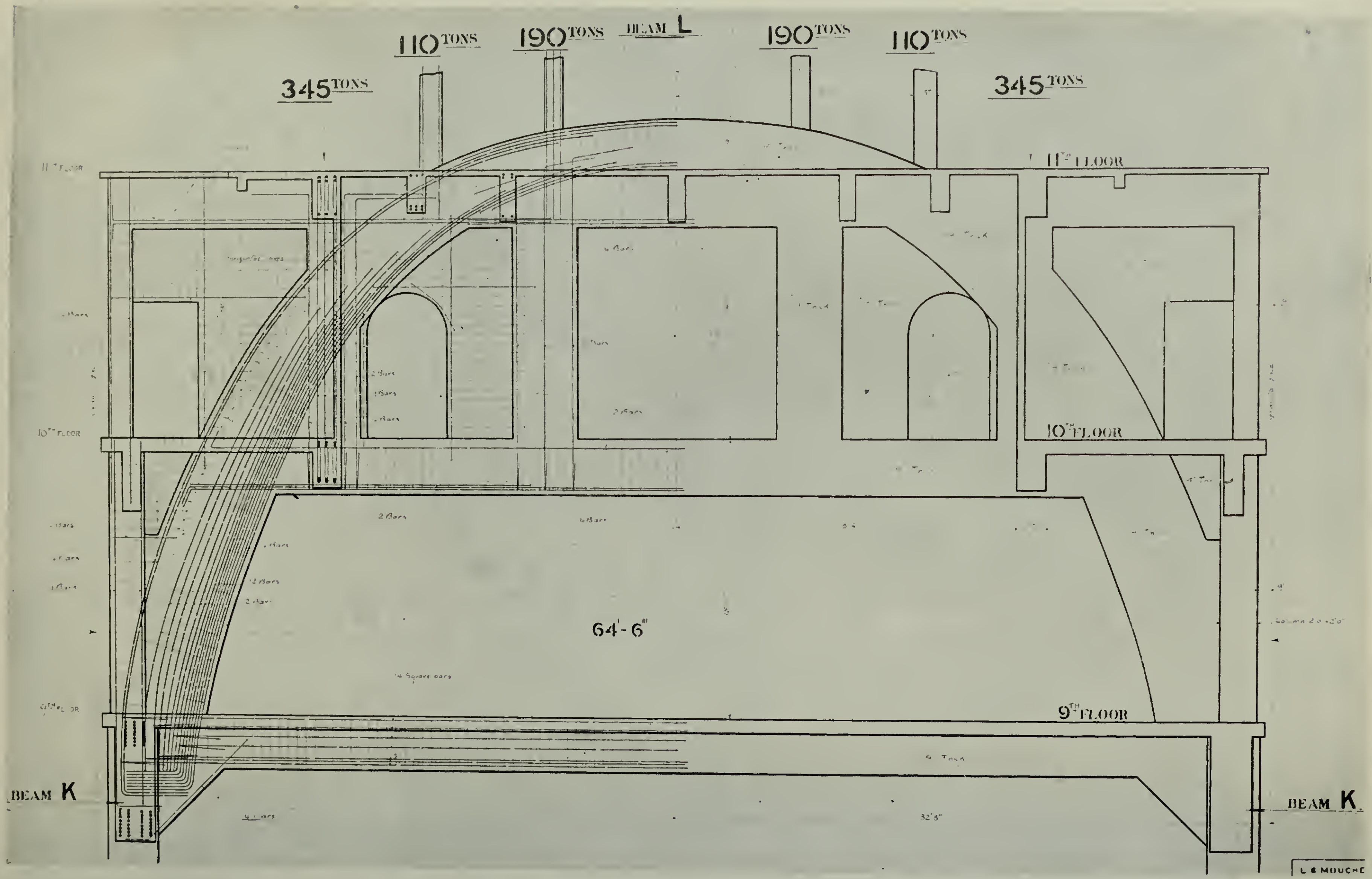


Fig. 5. Arch Beam under Tower.
The Royal Liver Building, Liverpool.

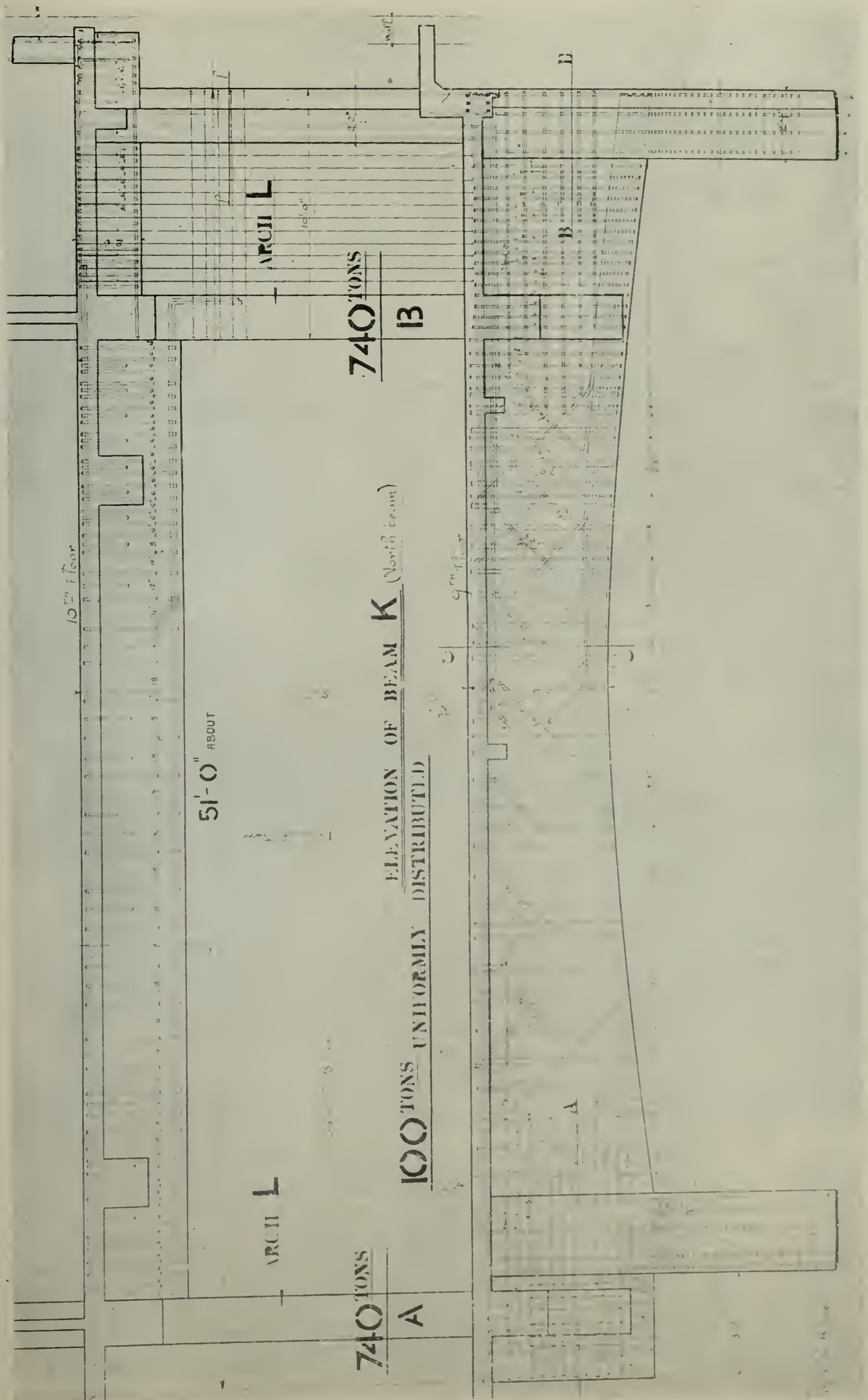


Fig. 6. Large Beams under Towers.
THE ROYAL LIVER BUILDING, LIVERPOOL.

of four bars in tension, two being straight from column to column, two being turned up at the ends, and two bars in the compression area. Stirrups of hoop are provided at varying distances throughout the length connecting the two sets of reinforcement, and giving provision against shear and diagonal tension. Generally speaking, these floor beams are spaced at 16-ft. centres, and the bays are filled in with hollow flooring as described below. The beams illustrated in *Fig*. 6 are constructed at the ninth and tenth floor levels in the west main tower. The upper beam has a clear span of about 38 ft., and carries two secondary beams and a part of the flooring. It is supported by columns, between which are two arches, the one at *A* springing from a cantilever extension of the lower beam, *K*, and the other at *B*, from the same beam, at a distance of 6 ft. from the main column. The length of the lower beam is about 51 ft., including the cantilever portion, while the clear span between the columns is 41 ft. 3 in. The depth at the centre is 5 ft. 6 in., and the disposition of the reinforcement is shown in the illustration.

One of the arches mentioned above is shown in *Fig*. 5, these having a clear span of 60 ft. and a rise of 32 ft., which carries them 2 ft. 9 in. above the eleventh floor, although springing from the beams, *K*, at the ninth floor level previously described. The total load on each arch is 1,480 tons, made up by the six concentrated loads as shown, and the thickness of the concrete is 1 ft. 9 in. As these arches are carried by the beams, *K*, the total load on each of the latter is 1,480 tons, *plus* an additional distributed load of 100 tons due to the ninth floor and its own dead weight, giving a total load of 1,580 tons. Another example of the arched type of beam is that shown in *Fig*. 7, which is a photograph showing the reinforcement in position previous to concreting. This beam carries concentrated loads to the total amount of 290 tons over a span of 42 ft. at the eighth floor level in one of the corner towers. An interesting example of concrete construction is that afforded by the arched members, carrying the glass roof over the central light areas at the first floor level, as shown in *Fig*. 4, which is a photographic view of the completed work. These arched ribs span 58 ft., and yet are of slender proportions and admirably adapted to their purpose.

The floor construction is of interest, as it will be readily understood that in a building of this size an efficient construction is necessary, which at the same time is as light as possible in order to reduce the dead load to be carried. The system adopted was the Hennebique hollow type, which consists of fireclay or concrete hollow tubes, usually measuring about 20 in. wide by 24 in. long by 7 in. high. These tubes are laid in parallel longitudinal rows between secondary reinforced beams, the latter being moulded in position between the tubes, which are temporarily supported on planks carried at each end by the main beams. This system has the advantage that elaborate centering is obviated, as the sides of the tubes form the shuttering for the vertical portion of the secondary beams. The top of the tubes are curved slightly, and a minimum covering of 1½ in. of concrete was employed, thus forming a floor construction 8½ in. thick.

The sides of the tubes are also slightly inclined outwards, the width at the bottom being less than at the top, this method preventing any tendency for the tube to drop out on the underside of the floor. These tubes also have the advantage that they can, if necessary, be made on the site, and thus any delay can be obviated which sometimes occurs with specially manufactured goods.

The walls throughout are formed with granite, which, generally speaking, had a thickness of 14 in., and this is carried by the skeleton construction at each floor level. This method rendered it possible to erect the masonry at several different levels simultaneously, as illustrated in *Fig.* 1, which is a photographic view taken when the skeleton construction was nearly complete.

The domes to the towers are formed in reinforced concrete and covered with sheet copper, while the clock dials in the west main tower required four circular openings, and some idea of the size of these can be gathered when it is mentioned that the clock face is slightly larger than that in the Clock Tower of the Houses of Parliament.

The building is equipped with no less than eighteen lifts, and in consequence all the staircases were kept down to the smallest possible size, and considered to be of secondary importance. They are, however, all formed in reinforced concrete, those in the upper part of every tower being of the spiral form. The contractors for the work were Messrs. Edmund Nuttall & Co., of Manchester.

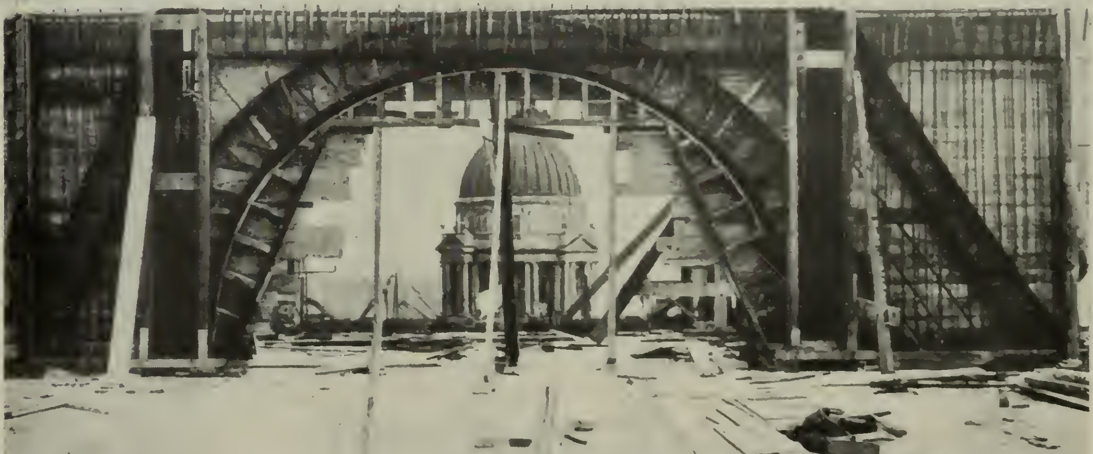
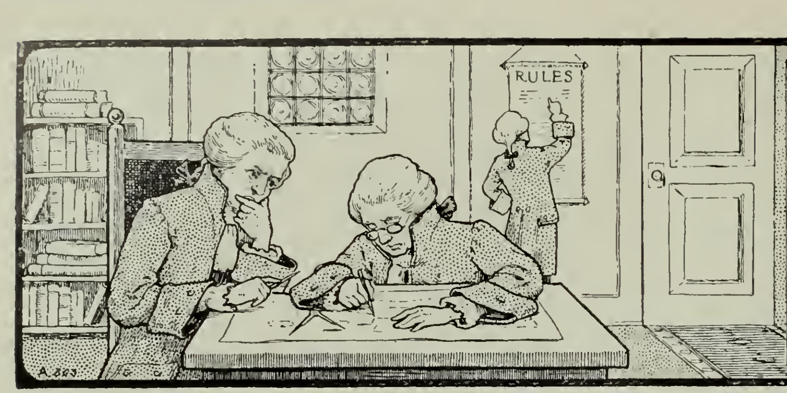


Fig. 7. Arched Beam, showing reinforcement in position previous to concreting.

THE ROYAL LIVER BUILDING, LIVERPOOL.



Formulæ for the Verification of Schemes in Reinforced Concrete

By MAURICE BEHAR,
Civil Engineer of the Ecole Nationale des Ponts et Chaussées de France.

The following article on Formulæ for the Verification of Schemes in Reinforced Concrete will be of interest to all those getting out calculations for work in that material.—ED.

WORKS in reinforced concrete may be divided into two distinct classes. One belongs to the domain of engineering, and includes public works in general, such as bridges, jetties, etc.; the other, which includes buildings, belongs to the domain of architecture.

For works included in the first-mentioned class, the reinforced concrete specialist engineer is often consulted directly by the owners.

In the second case the specialist is usually working under an architect appointed by the owners, who has a general control of the work.

It is therefore a matter of great importance to all parties concerned that architects should possess sufficient elements of control to enable them to judge the merits of the schemes which are submitted to their approval.

It is for this purpose that we publish the following formulæ, which are a simple application of the usual rules of the strength of materials.

FUNDAMENTAL FORMULÆ.

We know that if M is the bending moment in in. lb. in a transverse section of a beam, y, the distance of the neutral axis to the extreme compressed fibre, and y' the distance of the neutral axis to the extreme fibre working in tension, the rates of work in compression, c, and in tension, t, in the section to be considered, will be given by the formulæ :

$$(1) \quad c = \frac{My}{I}$$

$$(2) \quad t = \frac{My'}{I}$$

I being the moment of inertia of the section calculated with all the dimensions of the latter in inches.

The formulæ (1) and (2) are only applicable to homogeneous bodies working in flection, and having a plane of symmetry in the longitudinal direction of the body, the external forces being considered as contained within this plane of symmetry and normal to the neutral axis of the body.

The bodies in reinforced concrete which we have under consideration in this note fulfil these conditions, except the condition of homogeneousness of the matter.

In order that we should be able to apply to these bodies the general formulæ (1) and (2), we will admit, in conformity with the rules of the R.I.B.A., that the heterogeneous mass of concrete and steel is composed, in any transverse section, of concrete situated on one part of the neutral axis and working in compression, and of another element situated on the other side of the neutral axis, and composed of concrete and steel working to extension. In this latter portion, however, we will not take into consideration the work of the concrete, because the later material cannot properly be considered as working to extension.

Concerning the steel, we shall replace the section, A_t of the latter by a section, $m\ A_t$ of concrete having the same centre of gravity as the section A_t of steel.

The co-efficient of amplification, *m*, which theoretically is equal to the ratio of the co-efficients of elasticity of the steel to that of the concrete, shall be taken equal to 15.

It will be seen that by adopting this assumption the heterogeneous body of concrete and steel may be considered as a homogeneous concrete body, to which we may apply the formulæ (1) and (2).

SLABS IN REINFORCED CONCRETE.

Let us consider a slab in reinforced concrete with a width of 12 in. and a span 1 in.

Let *B*, *C*, *D*, *E* be a transverse section of this width, *e*, the thickness of the slab, *d*, the theoretical height—namely, the distance between the axis of the steel bars and the extreme fibre of the upper compressed portion, *B*, *C*, and let us call *y* the distance from the neutral axis to the face, *B*, *C* (*Fig.* 1).

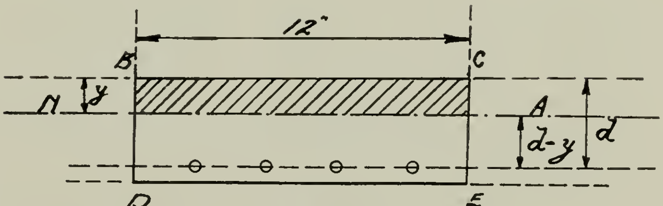


Fig 1

The elastic forces of the section, *B*, *C*, *D*, *E*, counteracting and equilibrating the external forces acting on one of the pieces of the slab under consideration, between this section and one of the supports, we may state that the moment of the compressed section, *B*, *N*, *A*, *C*, in relation to the neutral axis, *N*, *A*, is equal to the moment of the extended section $m\ A_t$, in relation to this same axis, *N*, *A*.

We have therefore,

$$12y \times \frac{y}{2} = mA\ \ (d-y)$$

or

$$(3)\quad 6y^2 + mA_t y - mA_t d = 0$$

This equation allows us to determine *y* when we know A_t and *d*.

The moment of inertia of the section, *B*, *C*, *D*, *E*, in relation to the axis, *N*, *A*, is equal to

$$I = \frac{12y^3}{12} + 12y \times \frac{y^2}{4} + mA_t\ (d-y)^2$$

or

$$I = y^3\ (1+3) + mA_t\ (d-y)^2$$

or

$$(4)\quad I = 4y^3 + mA_t\ (d-y)^2$$

Knowing *I* and *y*, we shall be able to apply the fundamental formulæ (1) and (2), which allows us to see if the thickness of the concrete and the section of the steel provided for in a slab are sufficient for the rates of work, c and t, specified for the concrete and for the steel.

BEAMS IN REINFORCED CONCRETE.

A beam in reinforced concrete is generally constituted by a slab in concrete, *B, C, D, E*, or, in other words, a portion of the floor which the beam supports, and the projection, *F, G, H, K*, underneath the slab. In the bottom part of this projection or beam we have the necessary section of steel to resist the efforts to extension produced by the bending moment, and the slab, *B, C, D, E*, usually counteracts the efforts of compression (*Fig.* 2).

When the portion, *B, C, D, E*, of the slab is not sufficient to absorb altogether the efforts of compression, we provide in the upper portion of the beam the necessary section of steel to take up the remaining efforts of compression which are to be absorbed.

Concerning the width of slab, b, working in compression at the same time as the projection or beam, we take, in accordance with the rules of the R.I.B.A., three-quarters of the bearing (or distance between the centre of each panel), or the one-third of the span of the beam and the smallest of these two numbers.

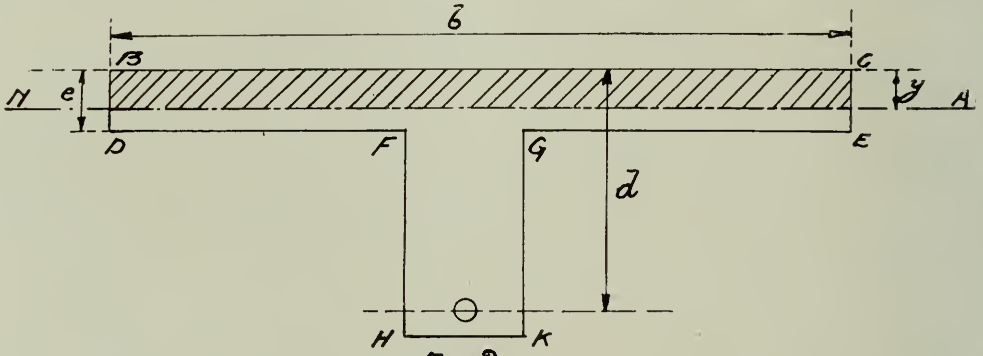


Fig 2

1st Case. Neutral Axis is situated inside the Slab.

Let us consider a beam, *B, C, D, E, F, G, H, K*. Let b be the width of the slab working in compression with the beam, y, the distance between the neutral axis and the extreme face of the slab working in compression. We have supposed here that the neutral axis is inside the slab.

Let A_t be the section of the extended bars. We have for the position of the neutral axis,

$$by \times \frac{y}{2} = mA \ (d-y)$$

or

$$\frac{by^2}{2} + mA_t y - mA_t d = 0$$

$$(5) \quad by^2 + 2mA_t y - 2mA_t d = 0$$

From this equation we may determine y.

Concerning the moment of inertia, it is given by the relation,

$$I = \frac{by^3}{12} + by \times \frac{y^2}{4} + mA_t \ (d-y)^2$$

or

$$I = \frac{by^3}{12} \ (1+3) + mA_t \ (d-y)^2$$

or

$$(6) \quad I = \frac{by^3}{3} + mA_t \ (d-y)^2$$

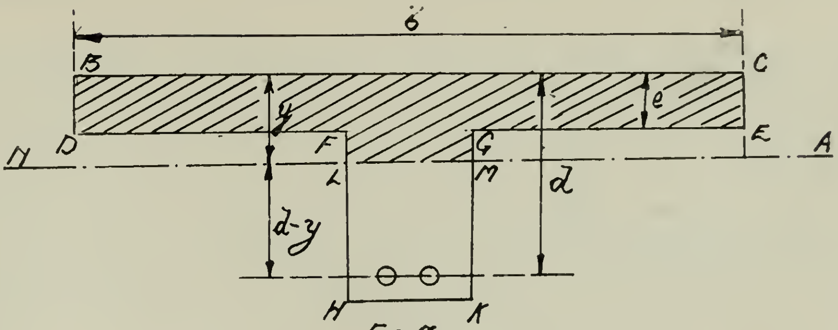


Fig 3

2nd Case. Neutral Axis is situated below the Slab.

We will neglect the small rectangle, F, G, L, M, working in compression. The neutral axis is given by the relation

$$be\left(y-\frac{e}{2}\right)=mA_t(d-y)$$

or

$$bey+mA_ty=mA_td+\frac{be^2}{2}$$

$$y(be+mA_t)=mA_td+\frac{be^2}{2}$$

$$(7)\quad y=\frac{2mA_td+be^2}{2(be+mA_t)}$$

The moment of inertia is given by the relation

$$(8)\quad I=\frac{be^3}{12}+be\times\left(y-\frac{\frac{e}{2}}{4}\right)^2+mA_t(d-y)^2$$

We will now apply the various formulæ which we have established above to the dimensions which we have given to the various elements of an application.

Notice that the above formulæ are all in conformity with the usual rules of the strength of materials.

We will prove that, at the weakest points of the structure, or, in other words, those points supporting the greatest stresses, the rates of work generally specified—namely, 600 lb. per sq. in. for the concrete in compression, and 16,000 lb. per sq. in. for the steel in tension, have not been exceeded.

NUMERICAL APPLICATION OF THE FORMULÆ.

The floor of the figure 4 is composed of slabs, secondary beams, and principal beams, supported by pillars in reinforced concrete. This floor has been calculated to support a superload of 2 cwt. per sq. ft.

Slab.

Thickness	$4\frac{1}{2}$ in.
Span between centre to centre of secondary beams	6 ft. 8 in.
Superload	224 lb.
Dead load	56 lb.
Total per sq. ft. ...	280 lb.

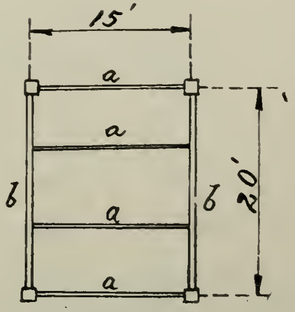


Fig 4

The maximum bending moment to which this slab must resist is therefore

$$M=\frac{280\times6'\ 8''^2}{12}=1038\text{ ft. lbs.}$$

A slab has been provided 4½ in. thick, reinforced with bars having a section of 0·286 sq. in. of steel per ft. run of slab.

The equation No. 3 of the fundamental formulæ gives us, for the position of the neutral axis,

$$6y^2 + mA_ty - mA_td = 0$$

In the slab with which we are concerned we have

$$d = 4\tfrac{1}{2}'' - 1'' = 3\tfrac{1}{2}''$$

$$A_t = 0{\cdot}286$$

We have, therefore, by substituting the letters for their values

$$6y^2 + 15 \times 0{\cdot}286y - 15 \times 0{\cdot}283 \times 3{\cdot}5 = 0$$

$$6y^2 + 4{\cdot}29y - 15{\cdot}015 = 0$$

$$y = \frac{-4{\cdot}29 + \sqrt{4{\cdot}29^2 + 24 \times 15{\cdot}015}}{12}$$

$$y = \frac{-4{\cdot}29 + 19{\cdot}46}{12} = 1''{\cdot}264$$

The formula 4 gives the value of the moment of inertia

$$I = 4y^3mA_t(d-y)^2$$

or else $I = 4 \times 1{\cdot}264^3 + 15 \times 0{\cdot}286\ (3{\cdot}5 - 1{\cdot}264)^2$

$$I = 29{\cdot}52$$

Knowing y and I, the formula No. 1 gives, for the compression of the concrete at the most compressed fibre,

$$c = \frac{My}{I}$$

n which M is the moment in in. lb., and y the distance between the neutral axis and the upper face of the slab.

$$c = \frac{1038 \times 12 \times 1{\cdot}264}{29{\cdot}52} = 534 \text{ lb.}$$

The working stress of the most compressed fibre of the slab is therefore below 600 lb. per sq. in., which is the maximum stress usually specified.

The thickness of 4½ in. given to the slab is therefore sufficient.

The working stress of the steel in tension is given by the formula No. 2 $t = \frac{My'}{I}$, and as $y' = d - y$, we have

$$t = \frac{1038 \times 12 \times (3{\cdot}5 - 1{\cdot}264)}{29{\cdot}52} = 944 \text{ lb.}$$

The working stress of the steel is therefore

$$944 \times 15 = 14160 \text{ lb. per sq. in.}$$

The working stress specified for the steel in tension is usually 16,000 lb. per sq. in.

The stress of 944 lb. given directly by formula No. 4 corresponds to a section of concrete equal to mA_t, introduced in the fundamental formulæ, in order that we might be able to consider the body in reinforced concrete as homogeneous ; as in reality the section of steel working in tension is A_t, and therefore, m, times smaller than the one given in the formulæ, which are applied for the verification ;

it is necessary to multiply the result of the formula No. 2 by m, in order to obtain the working stress of the steel in tension, and we have assumed that $m=15$

SECONDARY BEAMS (*a*).

Scantlings	6 in. by 11 in.
Free span	15 ft. – 11 in. = 14 ft. 1 in.
Slab application	6 ft. 8 in. by 280 = 1,867 lb.
Dead weight	= 69 lb.
Total per ft. run	= 1,936 lb.

The maximum bending moment in the middle of the beam is

$$M=\frac{1936\times 14'\ 1''^2}{10}=38397 \text{ ft. lb.}$$

The bars have been provided in tension placed in the lower portion of the beam, and having a total section of 2·53 sq. in.

VERIFICATION.

The theoretical height of this beam is

$$d=11''+4\tfrac{1}{2}''-2\tfrac{1}{2}''=13''$$

The width of the slab, b, working in compression with the beam is equal to three-fourths of the slab application width between secondary beams. (We have therefore

$$b=0{\cdot}75\times 6'\ 8''=5'\ 0''=60'')$$

Let us suppose that the neutral axis, N, A, is situated within the slab (*Fig* 5).

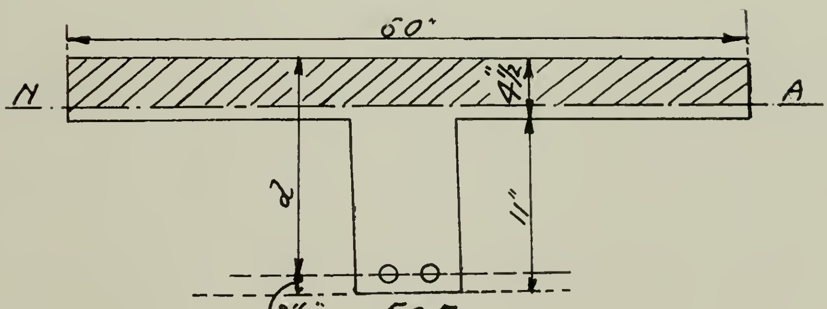


Fig 5

The equation No. 5 gives us, for the position of this axis,

$$by^2+2mA_ty-2mA_td=0$$

Substituting the letters by their values, we have

$$60y^2+2\times 2{\cdot}53\times 15y-2\times 15\times 2{\cdot}53\times 13=0$$

or $$60y^2+75{\cdot}90y-986{\cdot}7=0$$

hence $$y=\frac{-37{\cdot}95+\sqrt{37{\cdot}95^2+60\times 986{\cdot}7}}{60}$$

$$y=3''{\cdot}47$$

The neutral axis is therefore within the thickness of the slab.

If we had found for y a higher value than $4\frac{1}{2}$ in., the neutral axis would have been outside the thickness of the slab. It would then have been necessary to calculate y over again, applying the formula No. 7.

The moment of inertia of the beam is given by the equation No. 6.

$$I=\frac{by^3}{3}+mAt_1(d-y)^2$$

or

$$I=\frac{60\times 3{\cdot}47^3}{3}+15\times 2.53(13-3{\cdot}47)^2$$

$$I=835{\cdot}638+3446{\cdot}653=4282{\cdot}291$$

The application of the formulæ 1 and 2 gives us now, for the working stress in compression of the concrete, at the most compressed fibre,

$$c=\frac{My}{I}=\frac{38397\times 12\times 3{\cdot}47}{4282{\cdot}291}=374 \text{ lb.}$$

and for the steel in tension

$$t=\frac{M(d-y}{I}=\frac{38397\times 12\times(13-3{\cdot}47)}{4282{\cdot}291}=1025{\cdot}4$$

The real working stress of the steel in tension per sq. in. is equal to

$$15\times 1025{\cdot}4=15381 \text{ lb.}$$

The working stresses of 600 lb. for the concrete and 16,000 lb. for the steel, as generally specified, have not therefore been exceeded.

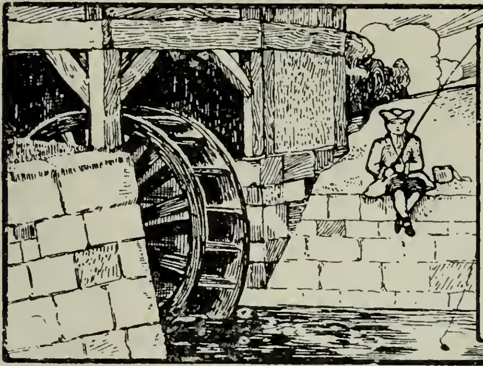
We have not thought it necessary to apply the formulæ of verification to the beam, *b*, the method to be followed being the same as for secondary beam, *a*.

Although the calculations for the verification of schemes which we have given herewith are somewhat lengthy, they have the advantage of being a strictly accurate application of the usual rules of the strength of materials, and the fundamental formulæ 1 and 2 are none other than those which are well known to all engineers and architects for the calculation of the strength of steel construction, or as applied to any other material.

It is our intention to give, in our next article on this subject, another method of verification by calculation more rapid than the one which we have given in this article, but less accurate in its results.

The second method to which we refer is based on the general theory of reinforced concrete given by Mr. N. de Tedesco, civil engineer.

In our next article we shall complete the study of the verification by giving formulæ to enable architects or engineers to verify that the materials provided in reinforced concrete beams are sufficient to resist shearing efforts, adherence, and negative bending moments over the points of support.



CONCRETE SILOS.

By C. W. GAYLORD and PERCY H. WILSON, Assoc.M.Am.Soc.C.E.

The following article, taken from a pamphlet issued by the Association of American Portland Cement Manufacturers, should be of interest to all those carrying out concrete work on the farm.—ED.

SILOS originated in France, but early in the 'sixties crops were successfully stored in Germany. During the last twenty years State Experimental Stations, founded by the United States Agricultural Department, have experimented with the use of forage stored in this way, and their great success has caused the building of many thousand silos in America.

A silo is the cheapest method of handling the crop, of storing it, and, finally, the best method of saving and realising the fullest value of the crop as feed.

Round silos are the best. The amount of building material required to construct a silo of a given capacity is less for a cylindrical shape than for any other form. The crop is also best preserved in a round silo, as this form renders packing easy.

While concrete may be used to advantage in any form of silo, it is peculiarly adapted to the construction of a round silo.

The silo must be air-tight. The air, which is necessarily confined in packing, causes the silage to ferment, but, if no additional air gets in, the silage keeps perfectly. If the air does get in, the silage moulds and the cattle will not eat it.

No building material can be made as air-tight as concrete. Builders of other kinds of silos recognise this fact, and recommend a coating of cement on the inside " to keep the silo air-tight." Most silos are used for about six months, during the winter, and the remainder of the year are empty. Wooden silos are like wooden tanks or buckets. When allowed to stand empty, they shrink, the joints open, and they leak ; the air-tight silo, tank, or bucket becoming a sieve. Coating on the inside with cement prevents this for about one year, when the shrinking is repeated, and this time the cement lining cracks and again the silo becomes a sieve. In order to keep it air-tight in this way, the cement coating has to be replaced every year.

A concrete silo, properly built, is air-tight. It does not shrink in the hot, dry weather. It does not swell up in damp weather.

The moisture going in with the silage should be kept in. This keeps the silage from " dry firing." A concrete silo is not only air-tight, but water-tight.

Silage settles after being packed, and even the slightest roughness is liable to catch the corn-stalks and prevent their settling evenly. The silage around the air-spaces formed in this way becomes mouldy and must be thrown away.

Concrete silos, when built with planed boards for inside wooden mould, are smooth, and while it is well to place a wash upon the inside, this never has to be replaced.

THE ADVANTAGES OF CONCRETE SILOS.

The acids formed by the slight fermentation in the silage, caused by the air left between the corn-stalks in packing, rot out wood and eat away metal silos, but these acids have no effect on concrete.

Every farmer knows the annoyance and danger to be experienced from rats. Nothing built of wood is rat-proof, and a wooden silo makes a fine nesting-place. A silo built entirely of concrete is absolutely vermin-proof.

A concrete silo is fireproof; and as concrete is one of the best known non-conductors of heat and cold, the food stored in it does not get injured or destroyed.

The silo shown in *Fig.* 1 is 16 ft. in diameter and 32 ft. high. The walls are 8 in. thick for the first 16 ft. of height, with an offset on the outside of 2 in. at this point, making the thickness of the wall above 6 in. The reinforcement in the walls consists of barbed fence-wire placed every 18 in. The depth of the foundation is 3 ft. 6 in. The roof is also of concrete. The silo has been in use for six years, and is as good to-day as when it was built, and has not cost anything in repairs.

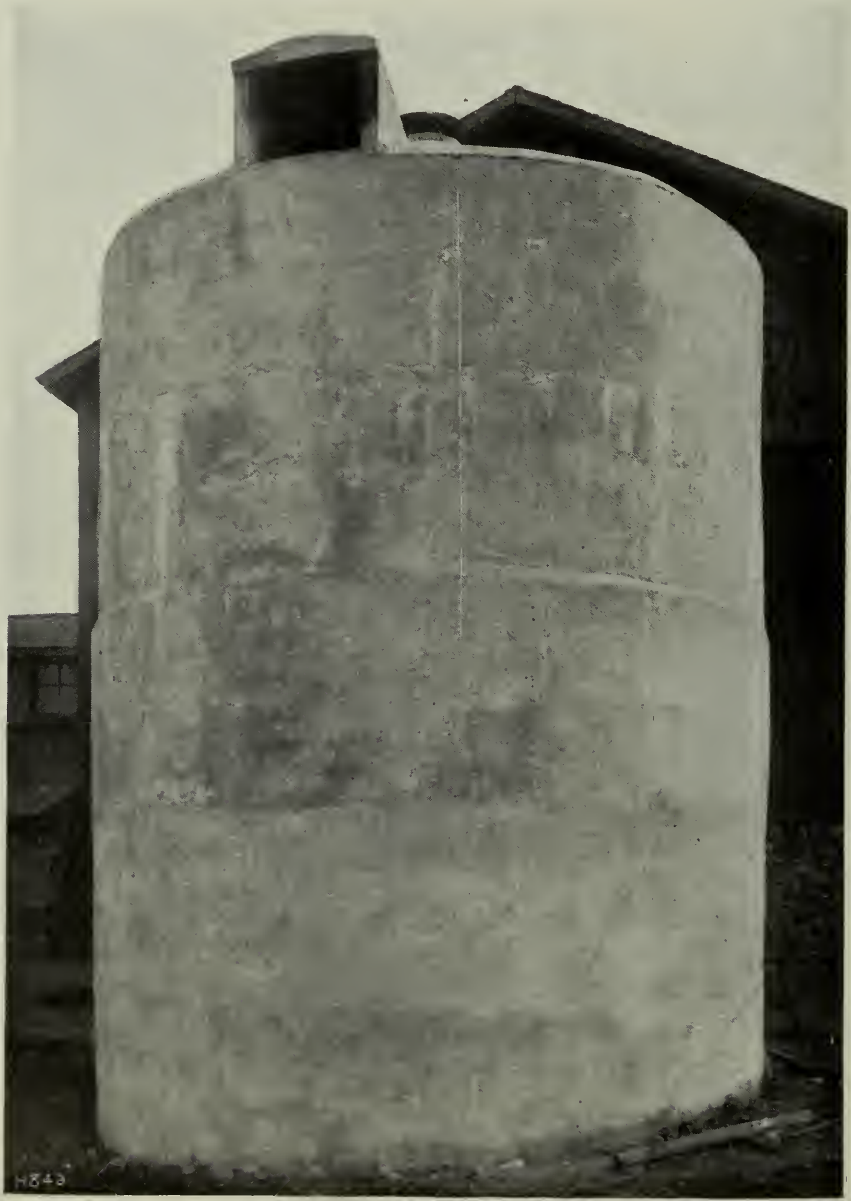


FIG. 1. ONE-PIECE CONCRETE SILO.

A concrete silo cannot be blown over, and if properly constructed, will last for ever. It cannot spring a leak due to expansion and contraction. No complicated rods are necessary to pull the sides together in summer when they dry out, or to allow for swelling when the silo is filled in the fall.

DIFFERENT KINDS OF CONCRETE SILOS.

Three kinds of concrete silos have been in successful use for several years. These are known as Monolithic (or solid walls) Concrete Silos, the Hollow Wall Monolithic Concrete Silos, and Concrete Block Silos ; all three are good, and in choosing between them, the cost, which is fixed by local conditions, should be the deciding feature, unless the location of the farm is so far north that the extreme cold in winter makes a hollow monolithic wall or hollow block wall silo preferable, to prevent the freezing of the silage.

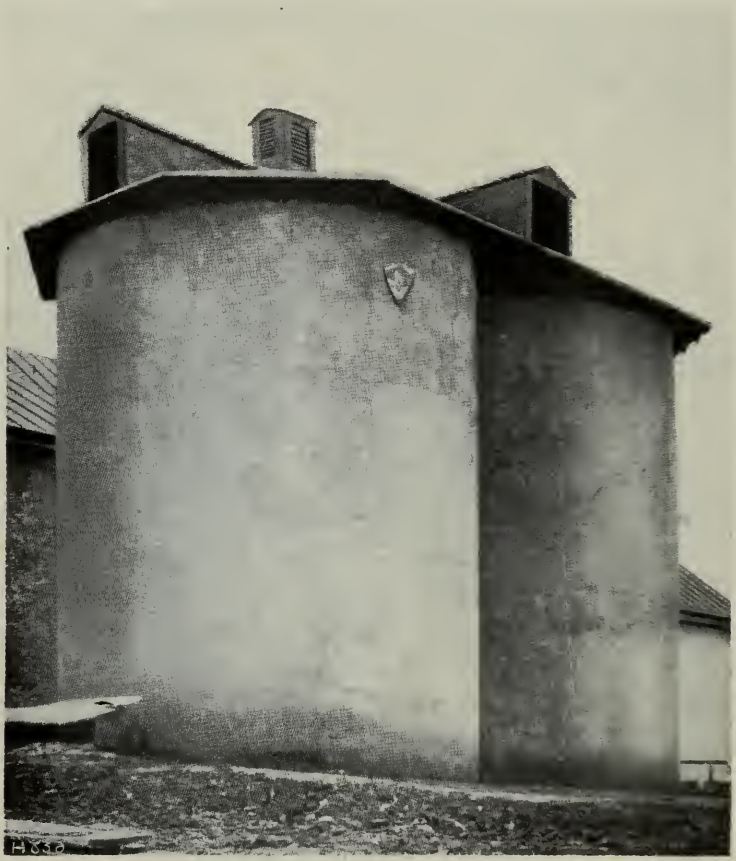


FIG. 2. DOUBLE SOLID WALL CONCRETE SILOS.

SELECTING THE SIZE.

The diameter, inside measurement, of a silo should never be more than one-half the height, and in practice it is not found advisable to make it over 20 ft.

Fig. 2 shows the two concrete silos in Kennett Square, Penna. They are 15 ft. 6 in. and 17 ft. inside diameter respectively. They are 40 ft. high, and extend 20 ft. below the ground-level. The walls vary in thickness from 10 in. at base to 7 in. at top.

CONSTRUCTION OF VARIOUS FORMS OF CONCRETE SILOS.

First decide the kind of concrete silo best adapted to the locality where it is to be built. Cost usually decides the class of concrete silo, except where extreme cold weather makes a hollow wall necessary.

All concrete silos preserve silage equally well. The effect of freezing silage should be considered in the Northwest, and the form of construction best adapted to prevent it is known as a hollow wall silo.

The solid wall concrete silo is cheap, easily built, and fulfils all the requirements of a perfect silo, and was first built with very thick walls, and without steel reinforcement. By using steel reinforcement,* a greater strength can be obtained with a much thinner wall. This saves in the quantity of concrete used, and also in the cost of material and labour.

For solid wall concrete silos, therefore, thin reinforced walls, rather than thick walls without reinforcement, are recommended.

The hollow wall monolithic concrete silo is constructed much the same as the solid wall, except that two walls are built instead of one, with a hollow air-space of about 4 in. between them. The inner wall is reinforced in the same way as in a single solid wall silo. The only reason for the outer wall is to form the air-space between the walls. This keeps the silage from freezing.

The cost of the hollow wall silo is about one-fourth greater than the solid wall silo. Except to prevent freezing, it has no advantage over the single solid wall silo. With both types of silos, any kind of doors, roof, chute, etc., desired may be constructed with equal ease.

The cement block or concrete block silo is built of circular, hollow blocks, laid in cement mortar, and reinforced with steel hoops, which fit in between every second or third course according to the size and depth of silo and size of hoop. When finished, the silo is usually painted both inside and outside with a cement mortar to insure air-tightness. The block silo, like the hollow wall silo, has a dead air-space in the walls which tends to prevent freezing, although the block wall is not quite as effective in this respect as the hollow wall, since the air-space is not continuous. The principal advantage of the concrete block silo lies in the ease with which it can be constructed. It requires less labour than either of the other types, after the blocks have been made.

LOCATION OF SILO.

In selecting a proper location for a silo the following conditions must be met: (1) The silo must be convenient for feeding; (2) must be located on solid ground; (3) no odours from the silage should enter the barn.

HOW TO BUILD A SOLID WALL REINFORCED CONCRETE SILO.

A silo, 10 ft. inside diameter and 25 ft. high—this being a silo of average size—is taken as an example.

Certain parts of all three kinds of silos are the same, and the building of these parts will be described once, under solid wall concrete silos.

Since the silo and its contents are very heavy, it must be built on solid ground, and the bottom of the foundation must go below the frost-line.

It is assumed that a depth of 5 ft. below the ground-level will be sufficient in all parts of the country. This depth will prevent any possibility of the silo being blown down, and usually furnishes good hard ground for the foundations to rest on.

Fig. 3 is a section of the excavation, showing how the hole in the ground would look if it could be cut exactly in half and could be seen from one side. This hole is dug larger at the top than at the bottom, to prevent the sides from caving in while the concrete is being placed. In the drawing, the distance from point O to A is the length of the string by means of which the size of the top of the hole is marked. This distance is made longer by 2 ft. than the radius or length of string that is used to measure the outside circle of the foundation footings. These different lengths give a slope to the side of the excavation sufficient in all materials, except very fine sandy soil, to prevent the dirt falling into the hole after the excavation is completed.

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* ¼ to ½-in. bars, Expanded Metal, wire mesh embedded in the concrete.

Excavation.—Having selected the site for the silo, the size of the hole for the foundation must be marked on the ground.

Referring to *Fig.* 3 :

1. Drive a stake in the ground at O, as near the centre of the site selected as possible. Place a nail in the top, and with a string tied to the nail mark off a circle.

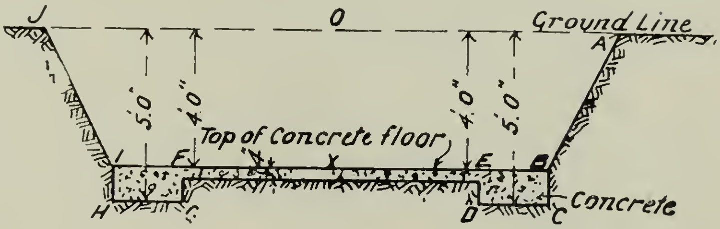


Fig. 3. Section of Excavation for Concrete Silo.

2. For the length of string, look in Table A (page 749) for the distance O–A, opposite the diameter of the silo you wish to build. In the case of a 10-ft. silo, this distance is 8 ft. 3 in.

3. Dig a hole 4 ft. deep, sloping the sides towards the centre.

4. Drive a stake in the bottom of this hole, at the point marked X. This should be as near the centre of the hole as possible. With a string attached to a nail in the top of this stake, mark off a circle. The length of string to be used is equal to X–B, and is found in Table A to be 6 ft. 3 in. for a 10-ft. silo. This circle will mark the outside limit of the concrete foundation of the silo.

5. Using the same stake, mark off another circle smaller than the one marked under 4. The length of the string to be used for this circle will be found in Table C under column X–E. For a 10-ft. silo this length will be 4 ft. 3 in. This is the inside diameter of the footing.

6. Dig out the earth between these two circles to a depth equal to the distance B–C, or 1 ft. for firm ground and 1 ft. 6 in. for medium ground.

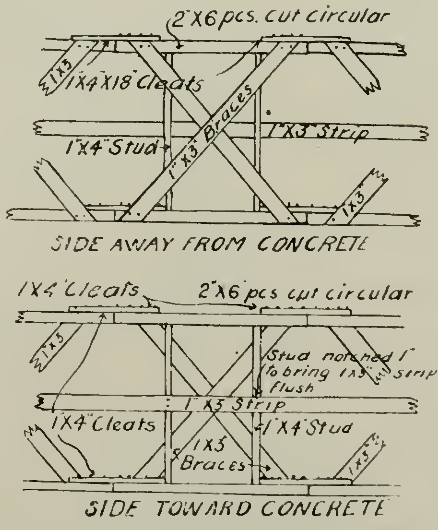


Fig. 4. Section of Framework of Circular Forms.

7. Dig out the earth in the inside of the trench, as described in 3, to a depth of 4 in.

8. Fill in the trench to a depth of 1 ft. and the centre of the excavation to a

depth of 4 in. with a 1 : 3 : 6 mixture of concrete of medium wetness. This will make the top of the concrete in the trench and in the centre the same level. The concrete should be thoroughly tamped, and the centre smoothed off.

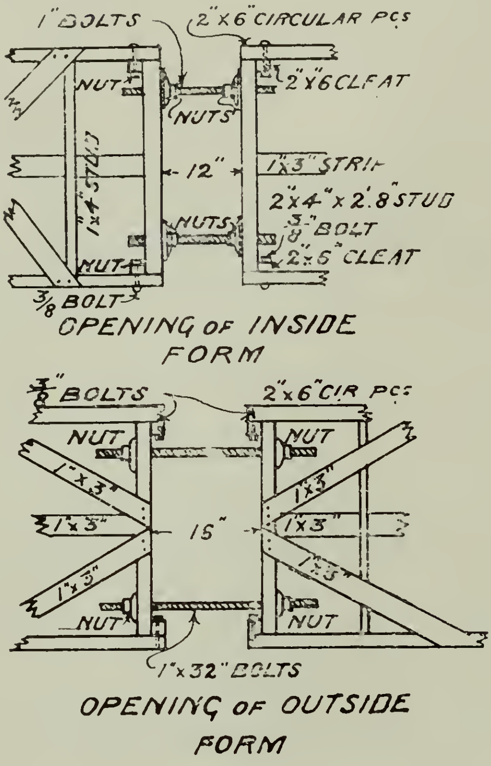


Fig 5. Arrangement of Adjusting Bolts

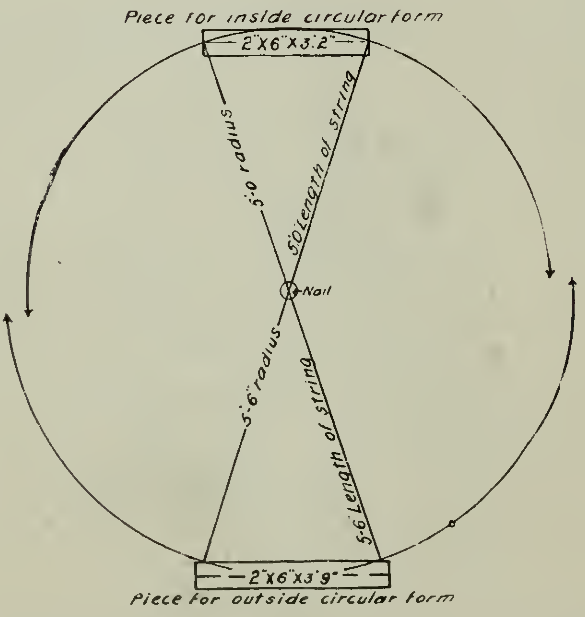


Fig. 6. Method of Making Pieces to be cut for Circular Forms.

This completes the excavating for and placing of the footings.

Table A shows the width and depth of the foundation necessary for firm and medium ground.

TABLE A.

Diameter of Silo in Feet.	Length of Lines.									
	For Hard or Firm Ground.					For Medium Ground.				
	O–A	X–B	X–E	E–B	B–C	O–A	X–B	X–E	E–B	B–C
	ft. in.	ft. in.	ft. in.	ft.	ft.	ft. in.	ft. in.	ft. in.	ft.	ft. in.
10	8 3	6 3	4 3	2	1	8 9	6 9	3 9	3	1 6
11	8 9	6 9	4 9	2	1	9 3	7 3	4 3	3	1 6
12	9 3	7 3	5 3	2	1	9 9	7 9	4 9	3	1 6
13	9 9	7 9	5 9	2	1	10 3	8 3	5 3	3	1 6
14	10 3	8 3	6 3	2	1	10 9	8 9	5 9	3	1 6
15	10 9	8 9	6 9	2	1	11 3	9 3	6 3	3	1 6
16	11 3	9 3	7 3	2	1	11 9	9 9	6 9	3	1 6
17	11 9	9 9	7 9	2	1	12 3	10 3	7 3	3	1 6
18	12 3	10 3	8 3	2	1	12 9	10 9	7 9	3	1 6
19	12 9	10 9	8 9	2	1	13 3	11 3	3 3	3	1 6
20	13 3	11 3	9 3	2	1	13 9	11 9	8 9	3	1 6

Note.—In a stiff firm clay O–A can be made 1 ft. shorter than shown.

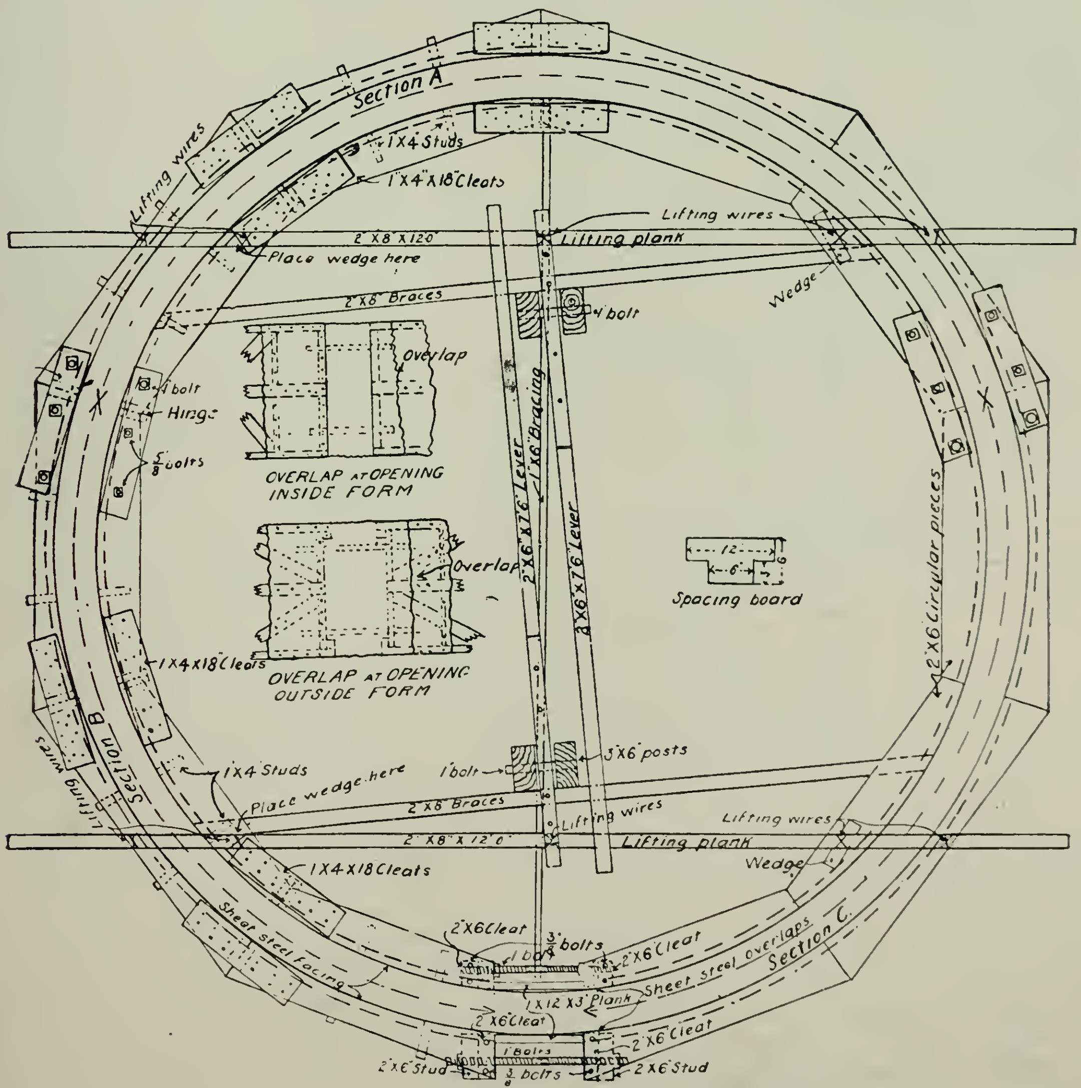


FIG. 7. ARRANGEMENT OF CIRCULAR FORMS AND SCAFFOLDING.

Cautions.—Be sure the earth under the footing is very dry and is as firm as possible. Do not remove the last 2 or 3 in. in the trench until just before the concrete is mixed. If rain interferes, always remove the softened soil and pump or bail out all water before placing the concrete.

If ground-water runs into the trench, tamp 2 or 3 in. of gravel pebbles (free from sand) in the soil before placing the concrete.

This excavation and concreting can be done in such a short time that, except in extreme cases, no trouble should come from rain. If, however, this should happen, slope the concrete floor slightly toward the middle, and make a hole in the middle of the floor into which the water will drain, and from which it can be easily pumped or bailed out.

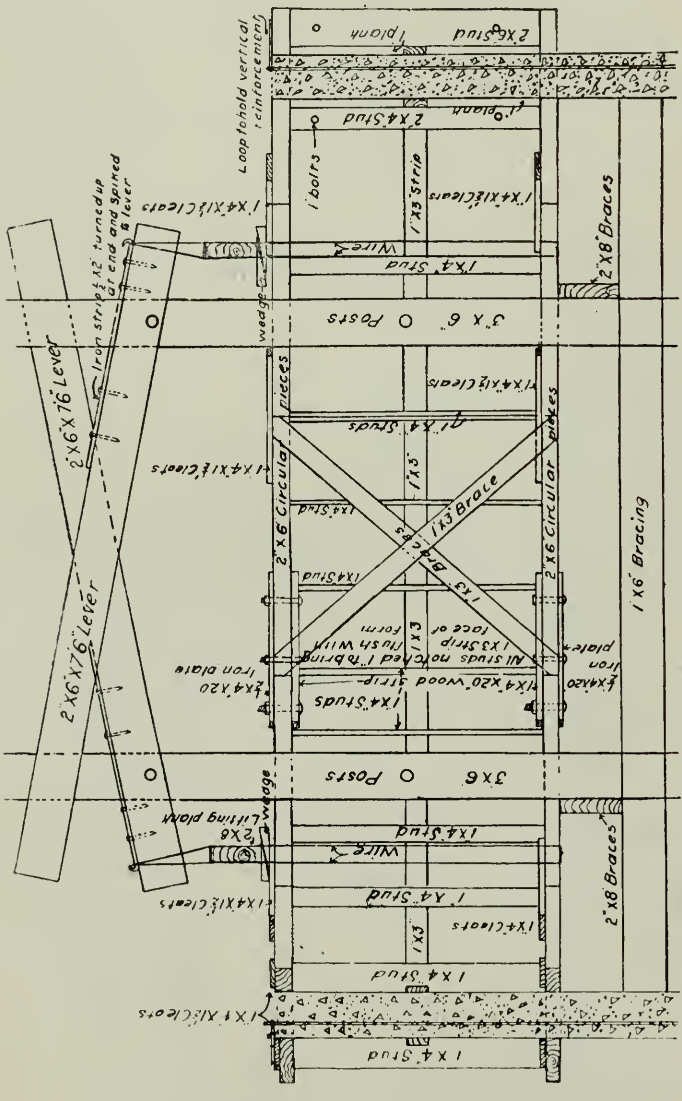


FIG. 8. SECTION OF SILO DURING CONSTRUCTION.

The foundation and floor are now complete and have been made without the use of forms.

If the ground is so soft that the trench cannot be dug with straight sides, a few stakes and boards can be placed around the edges of the trench to hold up the sides while the concrete is being placed. Be sure the trench is as wide as the width given in Table A.

If good ground cannot be found upon which to build the silo, the foundations should be strengthened by using the same kind of steel or wire used in the walls. This reinforcement should be placed after the first 3 or 4 in. of concrete has been deposited and while the concrete is fresh. After spreading this thin layer to a fairly smooth surface, lay the steel reinforcement on it. The reinforcement should be formed into rings or circles of varying sizes. The largest ring should be placed first and should come within about 3 in. of the outside edge of the concrete. Then another ring should be placed 6 in. inside of this first one, and then another 6 in. inside of the second, and so on until the entire surface of the footing has been covered. Short pieces of barbed wire cut just long enough to fit across the footing should then be placed over the rings. Spread the pieces of barbed wire out in a fan-like manner so that they are about 12 in. apart at the outside edge of footing. A footing reinforced in this way will settle evenly in soft ground without cracking the walls of the silo.

With the foundation and floor in place, the circular walls of the silo can be started at once. There are five operations in the constructing of the walls:

1. The forms must be built and set, ready for the concrete.

2. The reinforcement placed.
3. The concrete mixed, and placed in the forms around the reinforcement.
4. The forms removed, hoisted, and reset, ready for the next section of concrete.
5. Openings formed in walls for doors, placing of anchor-bolts for roof and chute, and other details.

The several operations will be explained in the order given, except item No. 2, which will be taken up separately under " Reinforcement," and item No. 5, which will be explained under the various headings.

(1) ***Wall Forms.***—The wall forms are circular in shape, one inside the other, the concrete being placed between them and thus forming the required wall. These forms are kept 6 in. apart, so that the silo walls will be 6 in. thick when completed. The forms are 3 ft. high, so that 3 ft. of the silo can be built at one time, without shifting forms. After the first 3 ft. of concrete is in place, the forms are loosened by means of the adjusting bolts shown in *Fig.* 4 (also details in *Fig.* 5), raised by the levers and again set in place by the adjusting bolts. This operation is repeated until the silo walls are built.

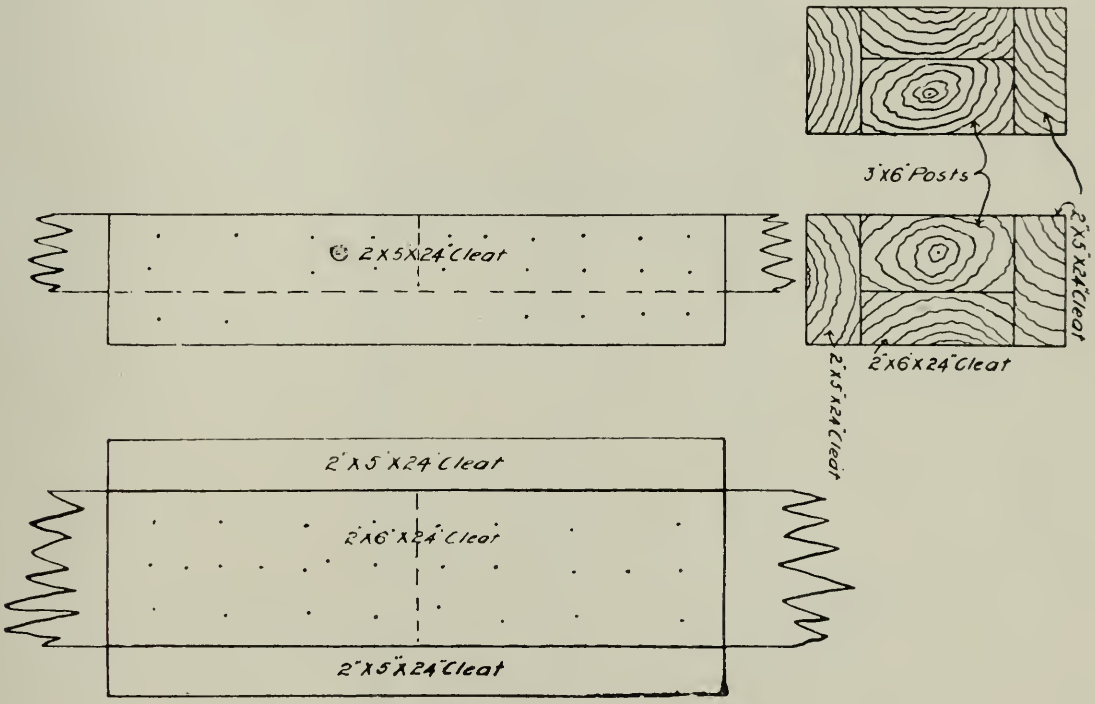


FIG. 9. METHOD OF SPLICING POSTS.

Both the inside and outside forms consist of pieces of 2 in. by 6 in. planks, cut circular.

Fig. 6 illustrates an easy method of marking the 2 in. by 6 in. pieces so as to saw them correctly. Take any level place in the house or barn and drive a wire nail in the floor. With a string attached to the nail, mark off a small length of a circle with a piece of chalk attached to the other end of the string, making the length of string 5 ft. for a 10-ft. silo. This mark gives the curve of the inside face of the form. From Table B we find the length of the 2 in. by 6 in. piece for an inside form for a 10-ft. silo is 3 ft. 2 in., and twenty of these 2 in. by 6 in. by 3 ft. 2 in. pieces are needed. Lay one piece of 2 in. by 6 in. by 3 ft. 2 in. on the curve described above and as shown in the upper half of *Fig.* 6.

Adjust the piece until the chalk line just comes to the outside edge and cuts both ends at an equal distance from the outside edge. Holding the 2 in. by 6 in. firmly, mark off the arc of the circle on it. By holding the string tight mark the cut for the two ends at the points where the curve leaves the 2 in. by 6 in. Use a good strong string, or, better, a light wire, so that it will not stretch. When this piece of 2 in. by 6 in. is cut along the marked lines it will be a templet for the rest. After cutting five or six pieces lay them out on the circle and see how they fit the curve, making any slight corrections necessary.

The templet piece for the outside form is made in exactly the same way, except that the length of the string is increased. A slightly longer piece of 2 in. by 6 in. is necessary, as shown in Table B, and the circular cut is taken out of the inside instead of the outside of the board. (See lower half of *Fig.* 6.)

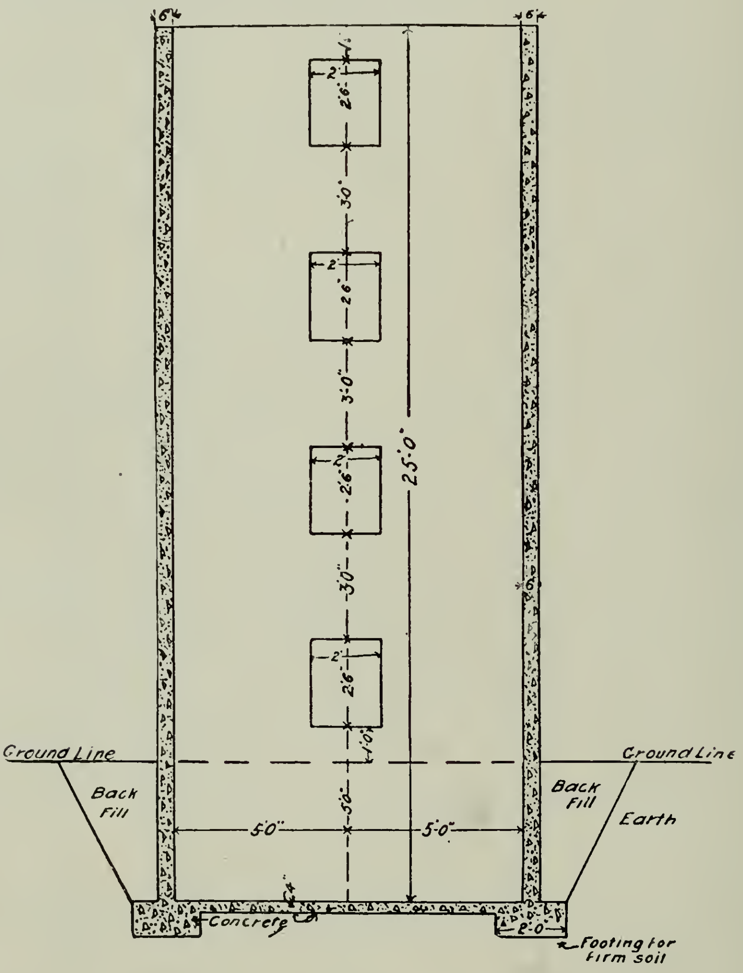
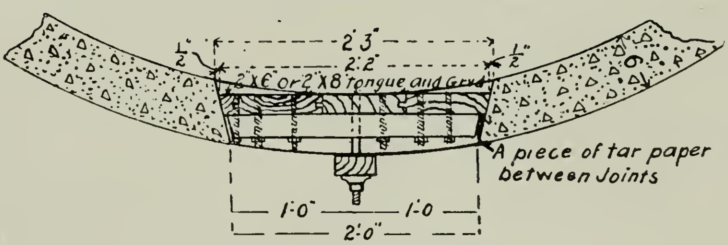


FIG. 10. VERTICAL SECTION OF SILO, SHOWING SPACING OF DOORS.

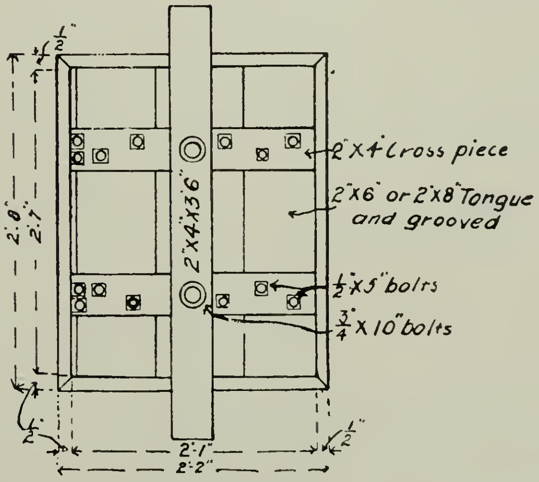
These planks are held together by 1 in. by 4 in. cleats. There are four complete circles of these 2 in. by 6 in. pieces, one at the top and one at the bottom of each form. The circles are held apart by 1 in. by 4 in. studding placed with their edges flush with the circular side of the 2 in. by 6 in. pieces, two studs to each piece of 2 in. by 6 in. plank. This framework is further braced by 1 in. by 3 in. diagonal braces—a pair of diagonal braces being used for each section of the circle. A 1 in. by 3 in. strip is sprung around the middle of the frame, the 1 in. by 4 in. studs being sawed out 1 in. to receive it on the edge toward the concrete. This makes the circular 2 in. by 6 in. pieces, the 1 in. by 4 in. studs, and the 1 in. by 3 in. strip all flush on the face of the form toward the concrete. On this circular surface is nailed the sheet steel (No. 24 gauge) which is the real form that holds the concrete. (See *Fig.* 4 for details.)

TABLE B.

Diameter of Silo in Feet	Inside Form.			Outside Form.			Number of Circular Pieces between Opening and Hinge.	Number of Circular Pieces to Make Section A.
	Radius of Circle.	Length of 2 by 6 Pieces.	Number Pieces Necessary.	Radius of Circle.	Length of 2 by 6 Pieces.	Number Pieces Necessary.		
	ft. in.	ft. in.		ft. in.	ft. in.			
10	5 0	3 2	20	5 6	3 9	20	3	14
11	5 6	3 6	20	6 0	4 3	20	3	14
12	6 0	3 2	24	6 6	3 10	24	4	16
13	6 6	3 6	24	7 0	4 1	24	4	16
14	7 0	3 9	24	7 6	4 4	24	4	16
15	7 6	3 5	28	8 0	4 0	28	4	20
16	8 0	3 8	28	8 6	4 3	28	4	20
17	8 6	3 11	28	9 0	4 6	28	4	20
18	9 0	4 1	28	9 6	4 8	28	4	20
19	9 6	4 4	28	10 0	4 11	28	4	20
20	10 0	4 7	28	10 6	5 2	28	4	20


1/2"
2'3"
2'2"
1/2"
2"x6" or 2"x8" Tongue and Grv.
A piece of tar paper between Joints
1'-0"
1'-0
2'-0"

HORIZONTAL SECTION



FRONT VIEW

FIG. 11. SILO DOOR.

Both inside and outside forms have screw-bolt devices for separating and pulling together the forms. Each has two sets of hinges to allow the forms to be separated or pulled together. These hinges, with the space for operating the adjusting bolts, divide the forms into three sections, lettered A, B and C in *Fig.* 7.

Fig. 7 is a view of the silo forms and scaffolding as it would look to a person above the silo looking down.

Fig. 8 is a section of the silo under construction taken straight across the silo. These two figures show exactly how the forms are constructed and operated.

Refer first to *Fig.* 7. As soon as the 20 circular pieces for both the inner and outer forms are made, as described under *Fig.* 6, fit section A around the circle on the level floor and nail on the cleats.

By referring to the last column in Table B, you can find the number of 2 in. by 6 in. pieces necessary to make this section.

Next, fit together the number of pieces necessary to make the two sections between the opening and the hinges, and marked B and C in *Fig.* 7. The next to the last column in Table B gives the number of pieces for each of these sections.

With the end of sections B and C about 1 in. from the ends of section A, to allow for the play of the hinges, it will be found that the 2 in. by 6 in. pieces will overlap at the opening. Where this overlap comes, the ends of sections B and C should each be cut back to make an opening of 12 in. The adjusting bolts are placed in this opening.

While the 2 in. by 6 in. circles are lying on the smooth floor, the holes for the hinges should be bored. These hinges consist of two ½-in. iron plates placed on both sides of the 2 in. by 6 in. pieces. They are fastened to the ends of sections B and C with two 1-in. bolts, and to the ends of section A with one 1-in. bolt. This bolt is not placed until the forms are in position, and is not drawn tight. This allows for the hinge action. (See *Fig.* 8.)

Next finish the three sections (A, B and C) separately, placing first the 1 in. by 4 in. studs, then the 1 in. by 3 in. cross-braces, and last the 1 in. by 3 in. strip. This strip can stop at the last stud next to the hinges.

Sheet Steel.—Nail on the No. 24 gauge sheet steel. Always have a stud at the vertical seam of the sheet steel, and if a horizontal seam is necessary, move the 1 in. by 3 in. strip up or down opposite the seam. Also at both the hinges let one side overlap the other about 2 in. Take care, however, that this extra lapping piece does not interfere with the free operation of the hinges. If the hinges are arranged as shown in *Fig.* 7, the overlapping piece at each hinge should be attached to section A. There should also be 14 in. of overlap at the opening in both the inside and outside forms, so that the full width of the top piece is next to the concrete. If there is any overlapping along horizontal seams, the top piece of sheet metal should always overlap the bottom piece.

The face of the sheet metal form should be painted with a thin coat of black or cylinder oil, and repainted whenever necessary to keep the concrete from sticking to it.

(*To be continued.*)

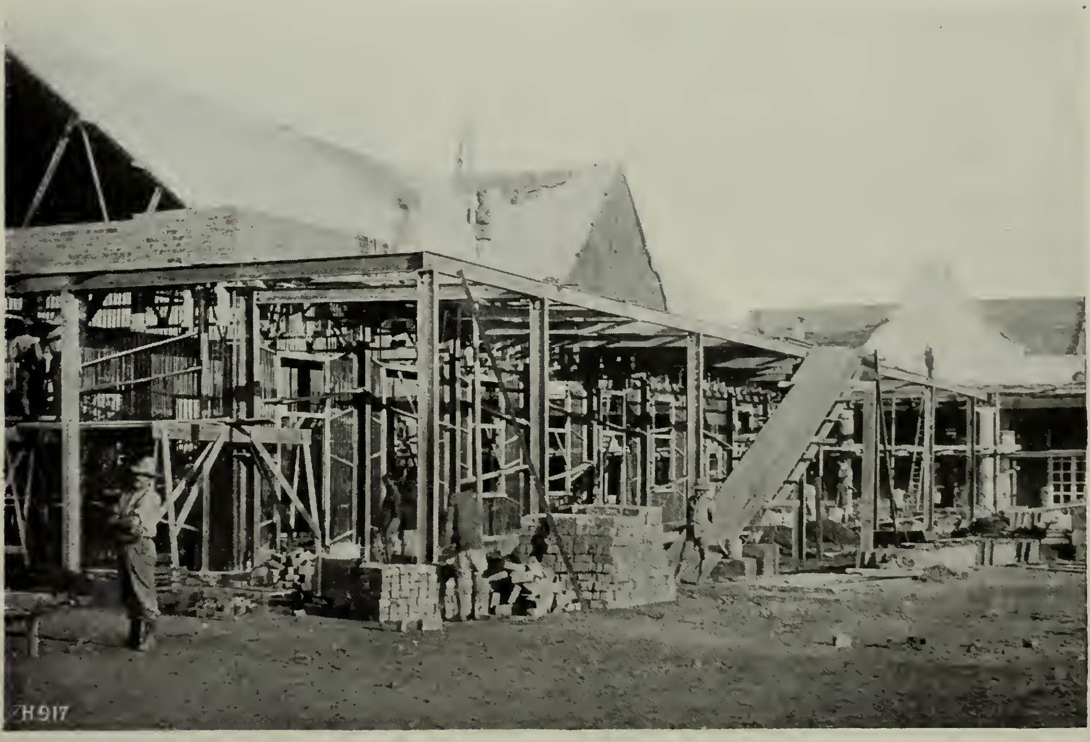
SOME EXAMPLES OF REINFORCED CONCRETE WORK IN SOUTH AFRICA.

It is very interesting to observe the headway that reinforced concrete is making in our South African Colonies, and we hope at a later date to describe further important structures that have recently been carried out in that material.—ED.

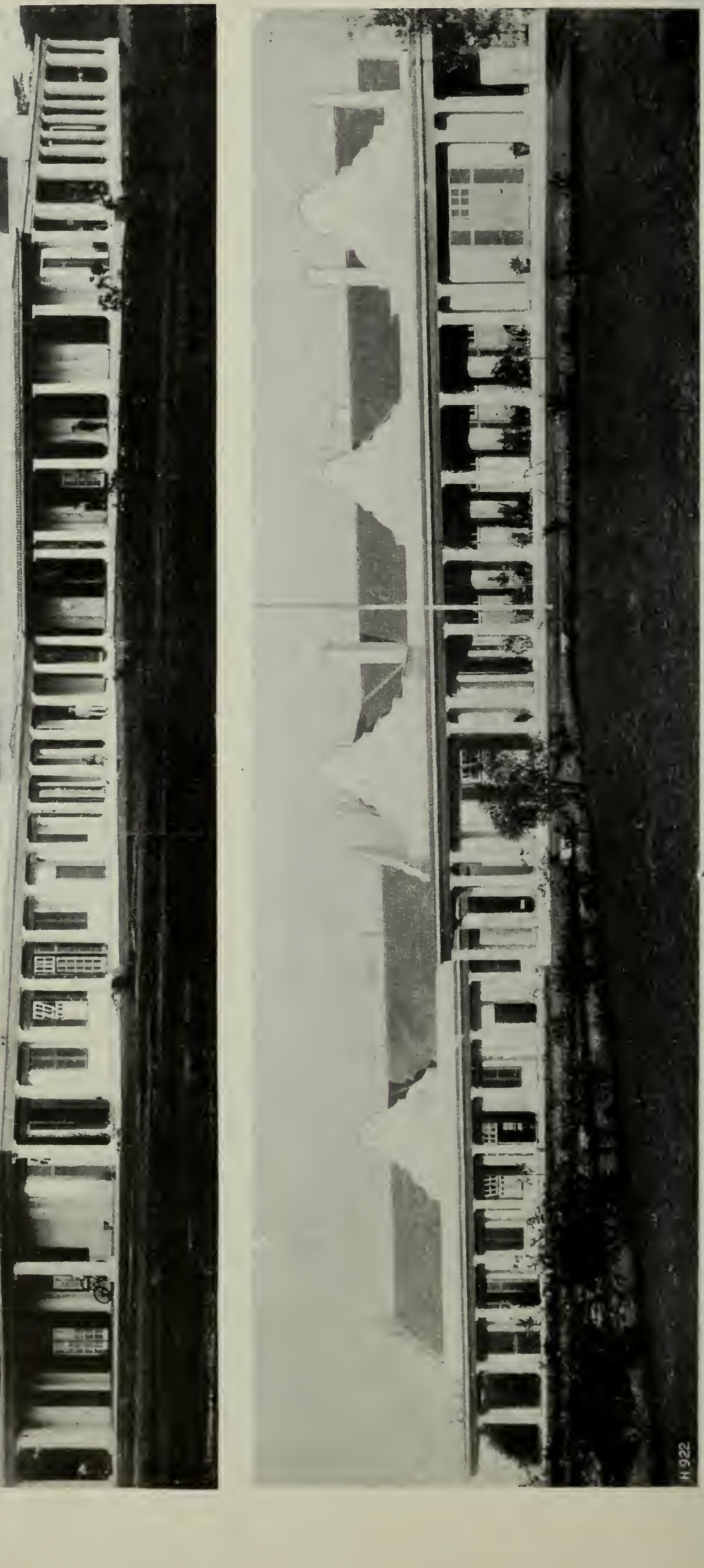
GOVERNMENT HOUSE, SALISBURY, RHODESIA.

THE building described in this article was erected in the remarkably short space of four months. It was built in connection with the opening of the first Union Parliament of South Africa, a tour of Rhodesia being included in the programme for that occasion, and it was decided to erect a house for the accommodation of the Royal visitors, which would subsequently act as a Government House. The time available was very short, but the building was quite completed within the four months available.

After consideration it was decided to use reinforced concrete as the most suitable method of construction for the country, and also owing to the rapidity to be obtained thereby.



View in course of construction.
GOVERNMENT HOUSE, SALISBURY, RHODESIA.



Two Views of Government House, Salisbury, Rhodesia.

The building is a single-storey structure 140 ft. long by 125 ft.; there is a detached kitchen block, 100 ft. long by about 30 ft. wide. The entire building forms a square, and is surrounded by a wide verandah.

The building is framed in steel stanchions which are founded on a concrete raft. The roofs, walls, partitions, and columns are all reinforced with "Hy-rib," and the floors are of granolithic concrete.

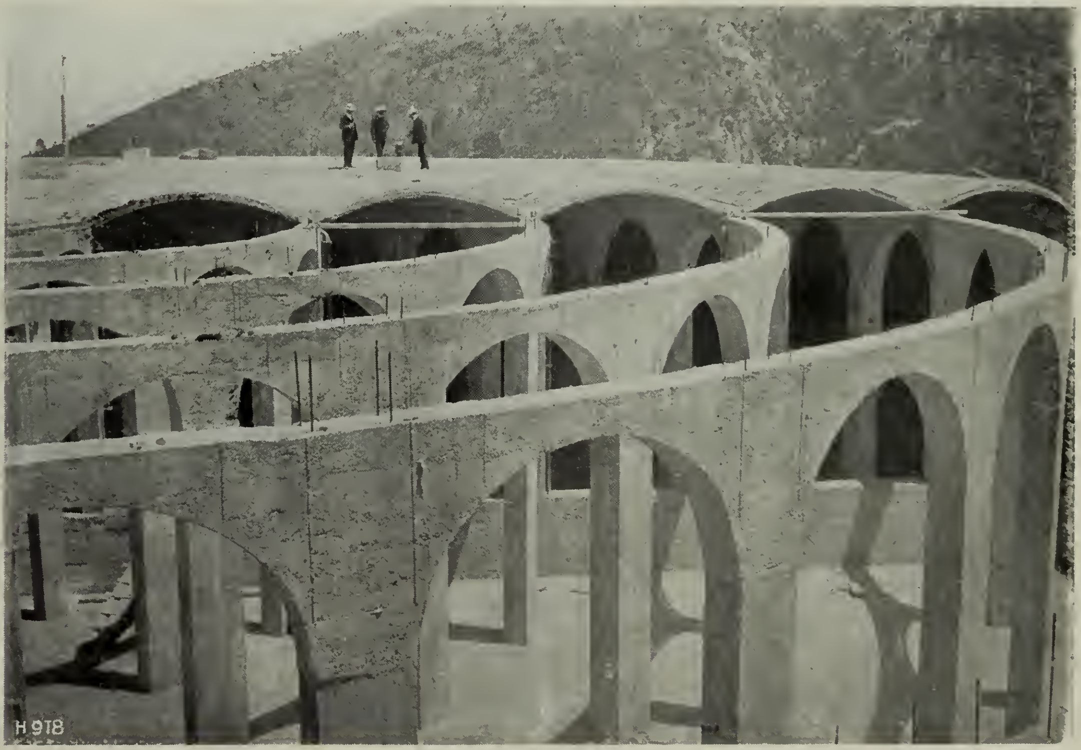
The walls are 3 in. thick, including inside and outside finishing; internal partitions are 2 in. thick. The roof slab is 3 in. thick, the flats being 3 in.

The outside walls run from floor to ceiling over columns; these outside walls and the internal partitions are 14 ft. high.

The architects for this work were Messrs. Detmar, Blow & Billery, of London. The Trussed Concrete Steel Co., Ltd., makers of the "Hy-rib" reinforcement, were entrusted with the details of the design, and the contractors were Messrs. Wm. Cubitt & Co.

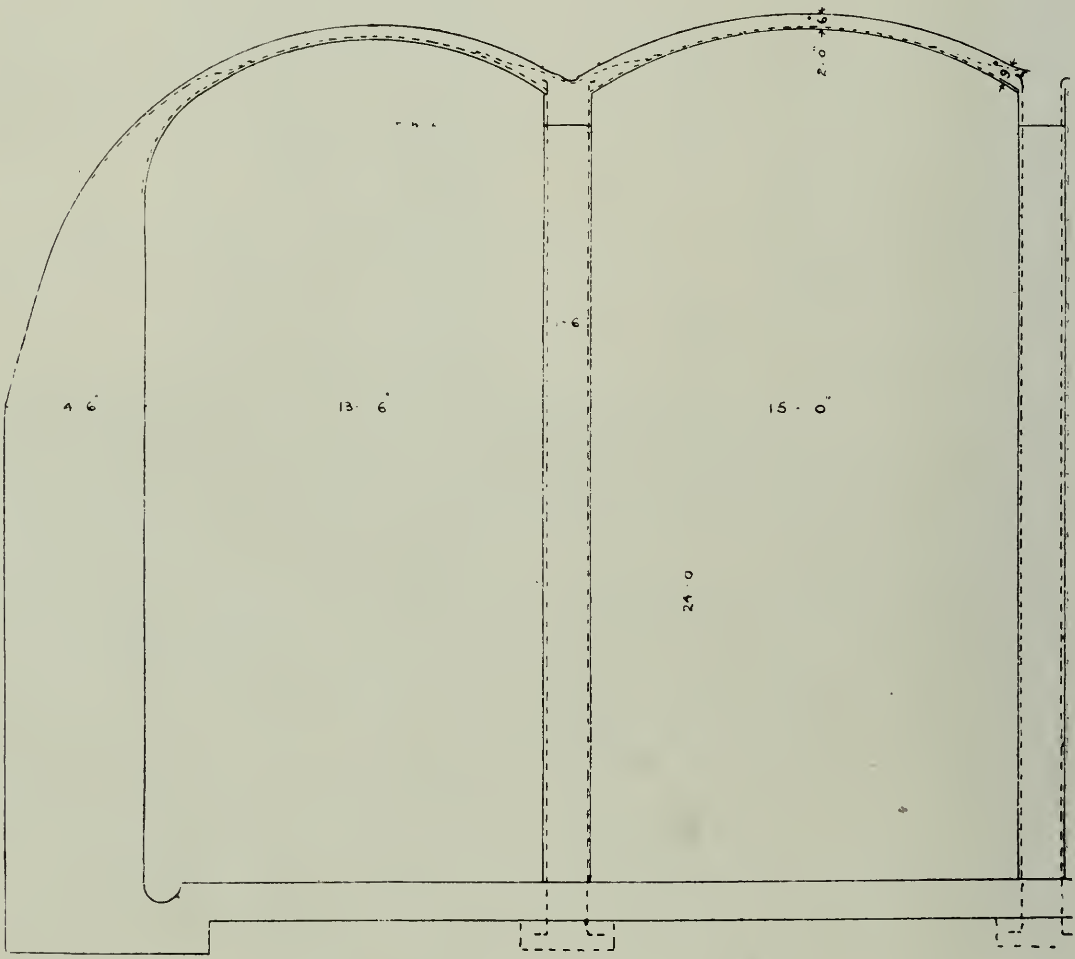
REINFORCED CONCRETE SERVICE RESERVOIR, CAPE TOWN.

This service reservoir is situated at Kloof Nek, a pass between Table Mountain and Lion's Head, at a height of about 900 ft. above sea level, which is the highest point in the celebrated circular tram ride round Lion's Head. Looking from the reservoir roof in a north-easterly direction, a magnificent view of Cape Town and Table Bay, with ranges of mountains far away beyond, can be seen; whilst to the north-west is seen the beautiful marine suburb of Camp's Bay, lying at the feet of the "Twelve Apostles" mountains.



View showing Reinforced Concrete Supports for Roof.
REINFORCED CONCRETE SERVICE RESERVOIR, CAPE TOWN.

The reservoir is circular in plan, with an inside diameter of 162 ft. The height to top water level is 24 ft., and, when full, is capable of holding 3,000,000 gals. of water. Its roof is supported by ninety-six reinforced concrete rectangular columns of cross sections varying from 1 ft. 6 in. by 1 ft. 6 in. to 2 ft. 6 in. by 1 ft. 6 in. The reinforcement of these columns consists of $\frac{5}{8}$-in. diameter mild steel rods at each angle, in single lengths, bent outwards into the concrete base, and also into the haunches of the segmental roof arches. The rods were spirally wound with $\frac{1}{8}$-in. diameter mild steel wire, with a pitch of 9 in. The columns in plan form five concentric circles, 15 ft. apart, on which are built the semi-circular arched walls, levelled on top for receiving the reinforced concrete roof.



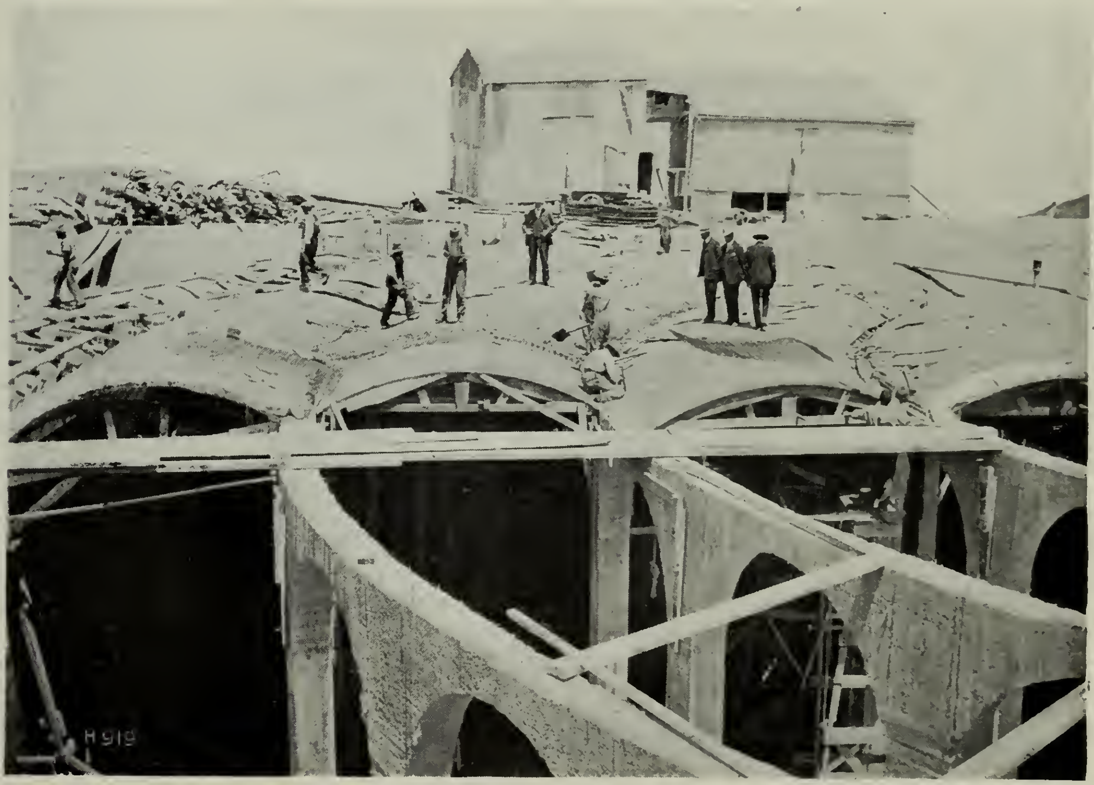
Roof arching.
Reinforced Concrete Service Reservoir, Cape Town.

The roof is formed of reinforced concrete, segmental arches springing radially from a central dome to the concentric walls in series, the outer arch merging into the main wall of the reservoir. The reinforcement consists of Expanded mild Steel of 3-in. mesh, with $\frac{1}{4}$-in. by $\frac{3}{16}$-in. strands, laid with a minimum lap of 6 in. The Expanded Metal is laid as near the intrados of the arches as possible, but particular care was taken that the steel was completely clothed by the fine concrete at every point. A further layer of Expanded Metal was laid near the extrados of the haunches of these segmental arches, and turned in to meet the Expanded Metal at the intrados.

The rise of the arches is 2 ft., and the minimum thickness 6 in., whilst the thickness at the springing is 9 in.

The major portion of the concrete used in the work was composed of 4 parts broken granite, screened to pass through a 1½-in. mesh sieve, 2 parts sand, and 1 of cement. For the segmental roof arches the stone was broken to pass through a 1-in. mesh sieve.

The stone was obtained from the Cape Town Council's own quarry, which is about a third of a mile from the site of the reservoir.



Roof in course of construction.
REINFORCED CONCRETE SERVICE RESERVOIR, CAPE TOWN.

The sand used was of excellent quality, and was obtained from the Cape Flats sand dunes, which have been formed in the past by winds blowing from the coasts of both the Indian and Atlantic Oceans across this flat stretch of country. These sand dunes have, of course, been well washed by rain water, and are quite free from any saline matter. The sand, when mixed with cement in the ratio of 2 to 1, and tested in the usual briquette form, gave results practically equal to those obtained with Leighton Buzzard standard sand.

All the cement used on the works had to conform in every particular to the British Standard Specification for Portland cement. Each consignment was tested in England, and certified before being dispatched, and again tested in Cape Town before being used on the works. All cement was aerated in a specially constructed building with a series of movable floors before being used.

Owing to the climatic conditions obtaining in that part of the world, it was deemed essential that every precaution should be taken to keep the new work moist and of even temperature. This was done by covering up all new work where exposed with sacking, which was kept wet until the concrete had well set.

All the concrete was made in an approved rotary mixer, and conveyed by means of trucks on light rails to the position where concrete was being laid.

The concrete was mixed to such a consistency so that when well punned all interstices in the stones were well filled with mortar, and blocks of concrete cut out of the finished work pointed to the homogeneity of the mass.

At the vertical joints, besides the usual V-shaped bond, two 1-in. diameter mild steel rods, 4 ft. in length, were inserted in the concrete 2 ft. on either side of the joint.

In both vertical and horizontal jointing the surface of the finished work was picked and washed perfectly clean, and then coated with cement mortar, mixed in the ratio of 2 to 1, before the new work was added.

The whole of the inside of reservoir to a height above water level, and also the extrados of roof arches, was rendered in cement mortar of 2 to 1 proportion, with a thin skimming of neat cement to form a hard and impervious surface. The surface of the concrete was pick-roughed, and thoroughly cleaned before the cement mortar was applied.

Agricultural drain pipes laid in the valleys of the roof arches carry the surface water to cast-iron down pipes passing through the roof and connected to the scour pipe.

The roof of the reservoir is covered with earth to a minimum thickness of 15 in., and planted with rough grass. The spoil heaps and places disturbed by the works have been planted with trees and shrubs to preserve the landscape appearance as much as possible.

On the mountain slopes above the reservoir a great deal of erosion has taken place. To prevent storm-water doing any damage to the reservoir, a concrete intercepting channel was constructed, and the water diverted from the direction of the reservoir by a reinforced concrete egg-shaped culvert 3 ft. 6 in. by 2 ft., and 2 in. in thickness.

When tested, the reservoir was found to be perfectly watertight, and no sign whatever of any leakage was then, or has since been, observed.

The work was commenced in May, 1906, and completed in May, 1908.

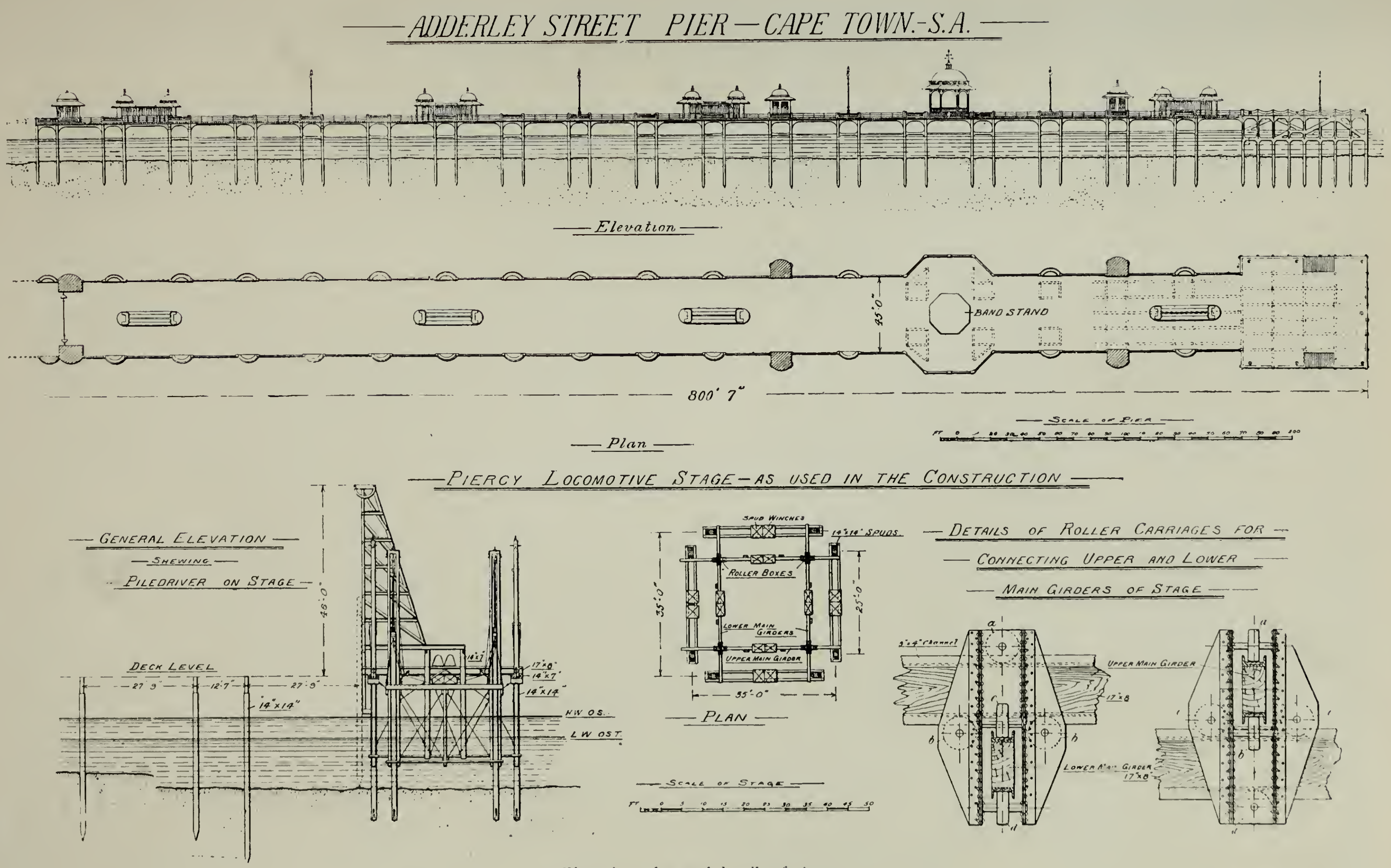
All concrete work was suspended during inclement weather.

The work was carried out by the Engineering Staff of the Cape Town City Council, and Messrs. Murray & Stewart, of Cape Town, were the contractors.

ADDERLEY STREET PIER, CAPE TOWN.

The intense commercial growth which took place in Cape Town some years ago, and the pressing need of important works of public utility led to the neglect of æsthetic considerations, especially along the sea front. A general desire, however, soon made itself felt to develop the natural advantages of one of the most beautiful bays in the world, and the construction of a promenade pier worthy of Cape Town, and other improvements were decided upon.

Sums amounting to £70,000 have been set aside for the purpose, and the



Elevation, plan and details of pier.
Adderley Street Pier, Cape Town.

design of the pier was approved, and its commencement authorised early in 1911. The work is being carried out departmentally by the Corporation of the City of Cape Town.

The pier is illustrated in elevation and plan in the first two figures of the drawing, and the following particulars will explain its general features :

It lies in the prolongation of Adderley Street, and its total length will be 1,400 ft., 800 ft. of which will be built on piles, the rest being formed by the present rubble mound jetty, which is to be raised and widened. The width of the pier is to be 45 ft., which is to be increased to 65 ft. at the bandstand and at the head of the pier.

Reinforced concrete has been adopted for the whole of the work, including the retaining walls, the bandstand, and the other erections on the pier.

The pier is to be supported on about 200 piles, each 14 in. square, with chamfered edges, and from 36 ft. to 44 ft. long. These are each reinforced by four vertical or longitudinal steel bars and transverse windings, and weigh from 3 tons to 4 tons each. They are arranged in groups of four, about 13 ft. by 10 ft., and connected together by strong horizontal bracing at high-water level ; all the usual diagonal bracing being omitted for the sake of appearance, and the reinforcement of the piles and the horizontal bracing adequately increased to compensate for this. The spaces between the groups of piles are about 27 ft. in length, and crosswise about 18 ft., and they are free from obstruction of any kind, so that boats can pass from one side of the pier to the other, and even up the middle of the pier between the piles. A better result could not be obtained even with cylinders, in spite of their prohibitive cost. At the landing stage end the piles are arranged to be closer together to enable it to withstand the bumping of comparatively large vessels, and also to carry a bathing platform and landing steps. Each pile is provided at its end with a strong iron or steel shoe, and they are driven after the manner of an ordinary timber pile by means of an electrical pile-driver mounted on an improved and simplified form of Piercy locomotive stage substantially similar to those used with such excellent results at Peterhead in Scotland, Whitby in Yorkshire, and by the Admiralty at Dover Harbour. The Piercy stage is a self-contained movable structure, which takes the place of the ordinary expensive temporary staging or falsework ; it is uninfluenced by tide or heavy waves, being always steady, and enabling the piles to be driven with great precision. The stage can be erected in all security on shore and walked out in the water to the work. The stage is moved ahead of the work as it proceeds. In the present instance the stage shown in the lower figures consists essentially of two pairs of main girders, which are crossed and connected at the four points of intersection by four two-way roller carriages also shown. This enables either pair of girders to entirely support the other pair while it is being moved. Each pair of girders is, of course, connected up and braced to form a square framework, at the corners of which the supporting spuds are situated. These spuds, of which there are eight in all, four for each frame, are raised or lowered as required by wire rope purchases and winches, and together carry the whole stage, which is moved ahead, sideways, or slewed as required by the pile-driving.

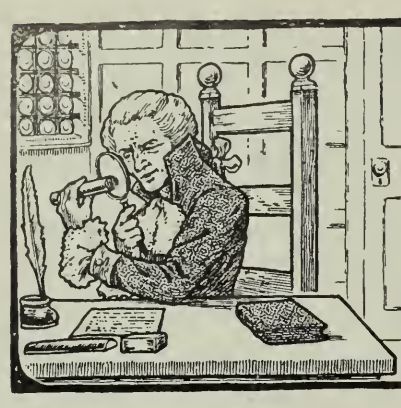
The stage normally rests on the whole of the eight spuds, but when the four spuds on one frame are raised, the said frame with its spuds can be moved on, or relatively to the fixed frame, when its spuds are then dropped, and those on the other frame raised, and so on, until the desired position is reached, when all the spuds are again lowered.

Fixed timber staging is thus entirely dispensed with, which will result in a saving of nearly £2,000 in the cost of the temporary works, besides enabling the work to be completed in much less time than would be required by the older methods.

The cross girders of the pier are exceptionally strong to aid in stiffening the whole structure, and the longitudinal girders, of which there are five to the width of 46 ft. 6 in. overall, are made beforehand and connected up with the cross girders and deck after being placed in position. The horizontal bracing is also moulded in advance, and connected up after the piles have been driven.

Test piles have been driven on the site to find the level of a reliable foundation and to determine the lengths needed for the piles as accurately as possible as it is advisable to avoid any subsequent alterations of any magnitude.

Some idea of the work may be gleaned from the following approximate quantities of material which will be used in its construction—200 tons of steel, 400 tons of cement, 1,600 tons of broken stone, 800 tons of sand, giving a total weight of 3,000 tons.



DR. F. VON EMPERGER'S METHOD OF TESTING REINFORCED CONCRETE BEAMS.

We present below particulars of Dr. von Emperger's method of testing reinforced concrete beams, as described in one of Messrs. Ernst & Son's publications referred to below. The original in the German language is obtainable at 4 marks, and these public particulars have been supplemented and various explanations and particulars sent us by the author personally.

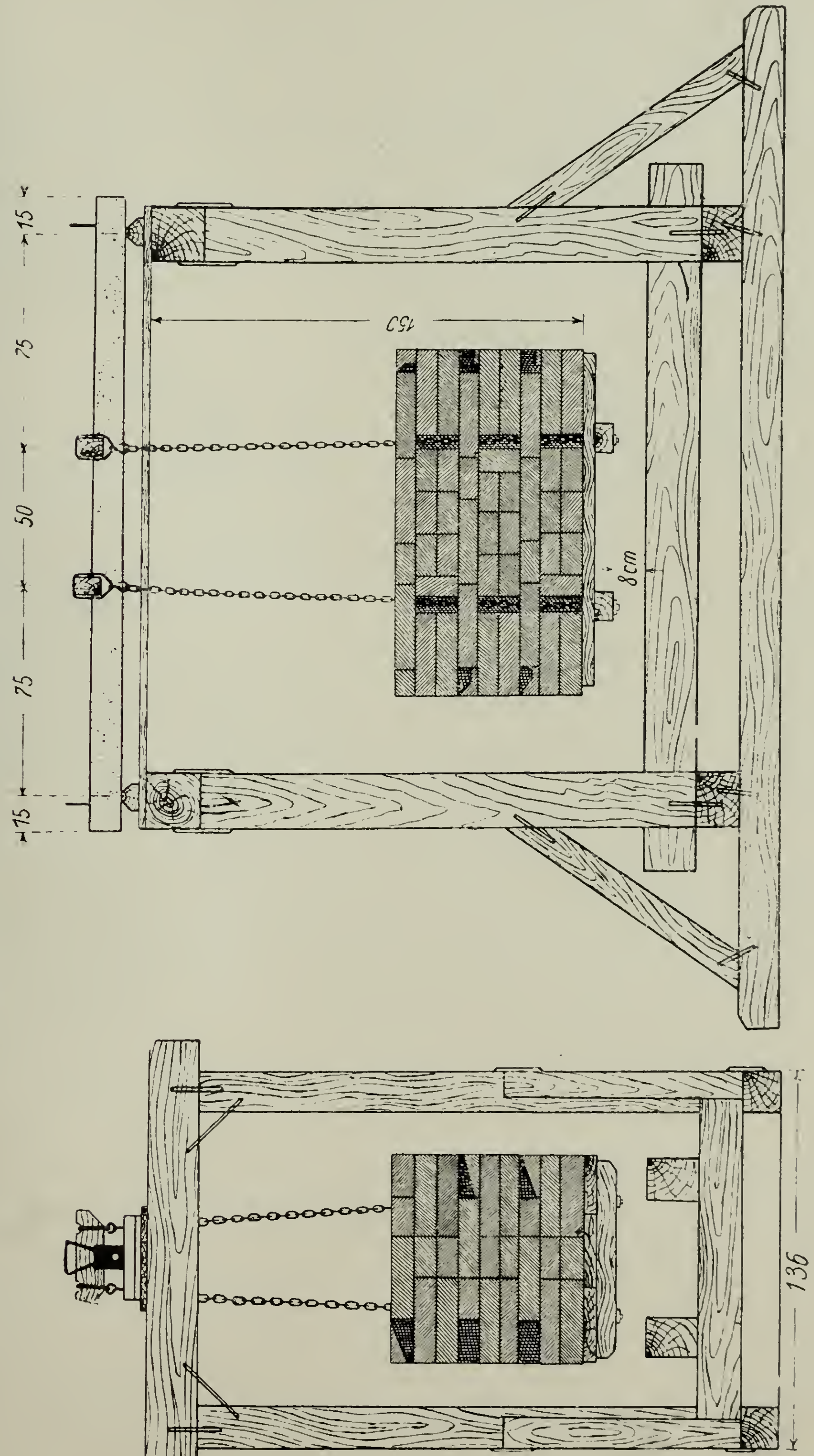
We believe his methods demand the most earnest consideration in this country, and if found as reliable as we understand they are, and as simple as the author urges, they might certainly be applied to jobs in this country with excellent effect.—ED.

In view of the unsatisfactory character of the results obtained from compression tests on concrete cubes, Dr. F. von Emperger proposed, as far back as 1903, that these tests should be abandoned entirely as a basis of calculation, and should be replaced by loading tests on specially prepared reinforced concrete beams. Although the method was then described in detail, it received little attention, and a further account has therefore been prepared by Dr. G. Neumann, and issued as Part XIV. of the excellent "Research Memoirs in Reinforced Concrete Construction," of Messrs. W. Ernst & Son, Berlin.

Defects of Cube Test.—The principal objections to the compressive tests with cubes are, that it requires a properly equipped laboratory with skilled assistants, and that small differences in the degree of ramming, the parallelism of the faces of the cube, etc., exert a very great influence on the results. The difficulty of ensuring that the cubes are fair samples of the concrete used on the job has contributed to bring the system of testing into discredit.

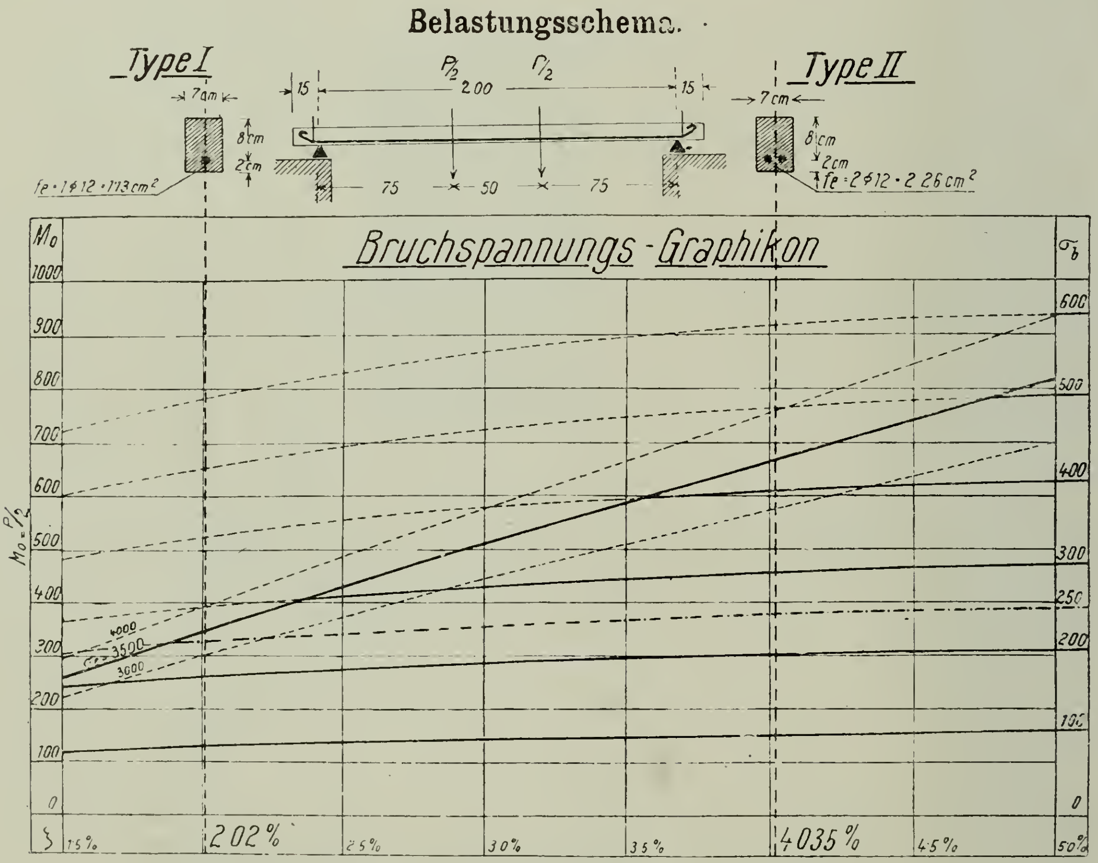
The New Test.—The new test is intended to be carried out on the spot, the test-beams being prepared from the materials there in use, and the testing apparatus being fitted up close at hand, from parts which are packed in portable cases, which also contain bent steel rods as models to be copied by the workmen preparing the test-beams. It is best to prepare four such beams for each test, two of which are reinforced with a single longitudinal rod (Type I.), and two with two parallel rods (Type II.). The beams are 2·30 metres (6 ft. 8 in.) long, 7 cm. (2¾ in.) broad, and 10 cm. (4 in.) deep. The reinforcing rods are 12 mm. (½ in.) in diameter, and are bent up and turned over at the ends as shown in the diagram on page 765.

Moulding the Beams.—Double-wooden moulds, lined with sheet iron, are used. After oiling, they are fitted together by means of distance pieces; two loops to serve as handles are placed in position, and the sides are accurately adjusted by means of a gauge until the middle third has exactly the correct width. The reinforcing rods are then laid in position on the distance irons and handles. The concrete is then introduced, and tamped in the same way as in the construction of a floor. The moulds may be removed in two or three days, after which care is taken that the beams are exposed to the same conditions of temperature and weather as the work to be controlled. If four beams are used, two are tested after three weeks, and two after six weeks, but for rapid tests intended to determine whether centering may be removed, a single beam is sufficient.



Testing Apparata.

Conducting the Test.—The framework used in making the loading test is shown on page 765. The two hardwood knife edges, with iron edges, are placed exactly 2 metres apart, and the load is then hung from two wooden riders, placed as shown at a distance apart of 50 cm. (1 ft. 8 in.). The chains must allow the loading platform to swing freely, without allowing too great a fall when destruction occurs. It is advisable to place a board (not a thick plank) immediately under the beam to receive the broken halves and prevent complete collapse. A vertical scale may be attached to this board at the middle point to measure the deflection before fracture. The load is applied by means of bricks, which are added symmetrically, according to a definite scheme, by two workmen, and are counted until fracture occurs. The mean weight of a brick is determined separately, and the breaking load is then made up of the weights of the bricks and the loading apparatus, and two-thirds of the weight of the beam. (When loading is applied at four points, corresponding with a test under distributed load, the whole weight of the beam must be included).



Graphical Diagram as proposed for Austrian and German Use.

Calculation of the Results.—Calling the breaking load P, the compressive stress reached in the concrete is, for Type I. of reinforcement, $\sigma_B = 0{\cdot}384$ P, and for Type II., $\sigma_B = 0{\cdot}3285$ P. It remains to be determined, however, whether this stress was the cause of fracture—that is, whether the maximum compressive strength was utilised. This is most readily determined by inserting $M_O = \frac{P}{2}$ in the graphical diagram here shown. It will be seen from this that for the best qualities of concrete it is advisable to use Type II., with 4 per cent. of reinforcement. The maximum stress obtainable in concrete by the use of this type of beam is considerably in excess of that ever attained in actual practice. The error due to accidental shifting of the reinforcing rods during the preparation of the beams does not exceed 2 per cent. of the stress.

The Use of the Graphical Diagram.—The diagram on page 766 has the percentage of reinforcement as abscissæ, and the values of the breaking moment, M_0, as ordinates. The dimensions of the test beams are so chosen that $M_0 = \frac{P}{2}$. The strength of the steel is taken as its elastic limit, which is generally 3,500 kg. per sq. cm., shown as a thick curve on the diagram. Actually, failure of the steel is very rarely observed. In the neighbourhood of its elastic limit, the steel unloads itself at the expense of the concrete, and the resulting shifting of the neutral axis upwards, and increase of the compressive stress in the concrete, causes fracture of the concrete, really from a secondary cause. If the value of $M_0 = \frac{P}{2}$ falls below the steel curve, fracture is due to failure of the concrete, and the strength of this may be determined by the aid of the second group of curves ; if above, fracture is due to the steel, and we cannot tell whether the maximum strength of the concrete has been reached or not.

An Example of the Use of the Test.—Dr. von Emperger gives a fully worked example of the test, in a case in which it was required to decide between two aggregates. The choice was between a machine-broken stone of known good quality, and the cheaper ballast dredged from the Danube, only one-quarter of which is broken in order to supply the missing fragments of medium size. Contrary to expectation, the natural ballast gave results throughout 25 per cent. better than the broken stone, although all the tests were fairly good. The limit of the steel was reached in two cases. The differences are attributed to the sand rather than to the coarser fragments.

The Factor of Safety.—The Prussian regulations require that in parts subjected to bending, the compressive stress in the concrete shall not exceed one-sixth of its compressive strength. This is usually taken to mean the strength of cubes in compression. The actual factor of safety is then $1{\cdot}6 \times 6 = 9{\cdot}6$, or nearly 10. A beam should then, after 28 days, show a compressive strength in the concrete of 384 kg. per sq. cm., which is quite impossible. The Swiss regulations would, under the same conditions, call for 240 kg. per sq. cm., an easily attainable figure. A comparison with the Austrian regulations, which give figures according with experiments, suggests that in the Prussian regulations the distinction between compressive strength in cube tests and in bending tests has been overlooked, and that the factor 6 should refer to the latter. With the materials available in Vienna, a strength of 250 kg. per sq. cm. should be reached easily after 6 weeks.

Suggested Specification.—It is suggested that the regulation of the Austrian Concrete Association should be modified to run as follows :

" In the regular course of building, four test-beams should be prepared for every 100 cubic metres of concrete, and should be tested before removal of centering in the case of floors, otherwise after intervals of 3 and 6 weeks. Such tests are to be repeated in case of any observed irregularity in the preparation of the concrete, especially at the approach of frost, whenever the temperature falls below +5° C., or sufficiently often to test any floors constructed in cold weather before the removal of their centering. These test-beams must be clearly marked by labels attached to their handles." Further, " the centering may be removed from any structural member when the specified minimum strength is reached, that is, 4 times the stress shown by calculation under full load." In good weather —that is, when the temperature is above 5° C.—this strength is reached in about a week.

The Strength of Concrete.—A graphical comparison of Dr. von Emperger's results with those obtained by Professor Mörsch and by Professor von Bach, shows that greater uniformity is found in the bending tests than in the compression tests with cubes. A few of Professor von Bach's results with compression tests of 1 : 2 · 3 mixtures may be quoted. All the cubes were tested when 45 days old :

Cement, Dresden pit sand, and Rhenish gravel, 238 kg. per sq. cm.
Cement, Rhenish sand, machine-broken basalt, 233 kg. per sq. cm.
Cement, crushed basalt sand, and machine-broken basalt, 178 kg. per sq. cm.
Cement, broken limestone sand, and Rhenish gravel, 191 kg. per sq. cm.

These results are in very good agreement with those obtained from Danube ballast. The decrease in strength obtained by using crushed stone instead of sand is very marked in all cases.

The average variation in the results of the bending tests is about 7 per cent. to 8 per cent. of the mean value, these variations being attributable to differences of temperature, moistness of air, etc., and in some cases also to the fracture of the beam taking place at different parts. The corresponding compression tests with cubes exhibit much greater irregularities. Excluding the most irregular values, the ratio of the breaking stress in bending tests to that in compression tests is from 1·3 to 1·6 : 1.

Tests made on the works at temperatures below 5° show a great diminution in the strength of concrete, but the minimum permissible strength was always exceeded after 23 days, so that the centering could then be safely removed. This factor is of such great importance that provision is made on the testing sheets for the entry of the daily maximum and minimum temperatures.

Size of Beams.—It is well known that different values of the compressive strength are obtained by using cubes of different sizes. The experiments with beams conducted by Professor von Bach, Professor Mörsch, and the Amsterdam Cement Works were with test-beams of very different dimensions, but little variation of the results was observed. A diminution of resistance under bending load occurs when the section is T-shaped instead of rectangular.

Conclusions.—The cheapness and simplicity of the test, as well as its trustworthiness, are adduced as reasons for its introduction as a means of systematic control of building operations. The same advantages make it a very suitable means of instruction in colleges and classes where engineers and others receive training in constructional engineering. For this reason, it has already found an entrance into the systematic courses of instruction in several important colleges.

REINFORCED CONCRETE WORK AT BRIDLINGTON

By E. R MATTHEWS, A.M.Inst.C.E., Borough Engineer, Bridlington.

It is with great pleasure that we publish an article on various examples of reinforced concrete in municipal work in Bridlington.—ED.

Reinforced concrete has been freely used in municipal engineering work at Bridlington in a variety of ways, but chiefly in the construction of retaining walls and roofs, and in this short article a brief description is given of these, including the work in connection with the construction of the new lavatories and shelter on the marine drive.

Designs were sent in by the Chain Concrete Syndicate, of Leeds, and were approved by the author, and subsequently by the Local Government Board, and a thirty years' loan was granted for same. Other designs and prices have since been invited, and the Council have accepted those of the Trussed Concrete Steel Co. for this work, their price being the lowest. A plan and section are shown on page 770.

The design includes the erection at the back of the proposed lavatories and shelter, and extending the full length of same, of a reinforced concrete retaining wall. It is 13 ft. in height, and is strengthened by buttresses as shown. The wall is 7 in. in thickness at the base, and 4 in. at the top. The width of the foundations is 6 ft., thickness 9 in., and a longitudinal beam 18 in. by 8 in. extends the full length of the wall.

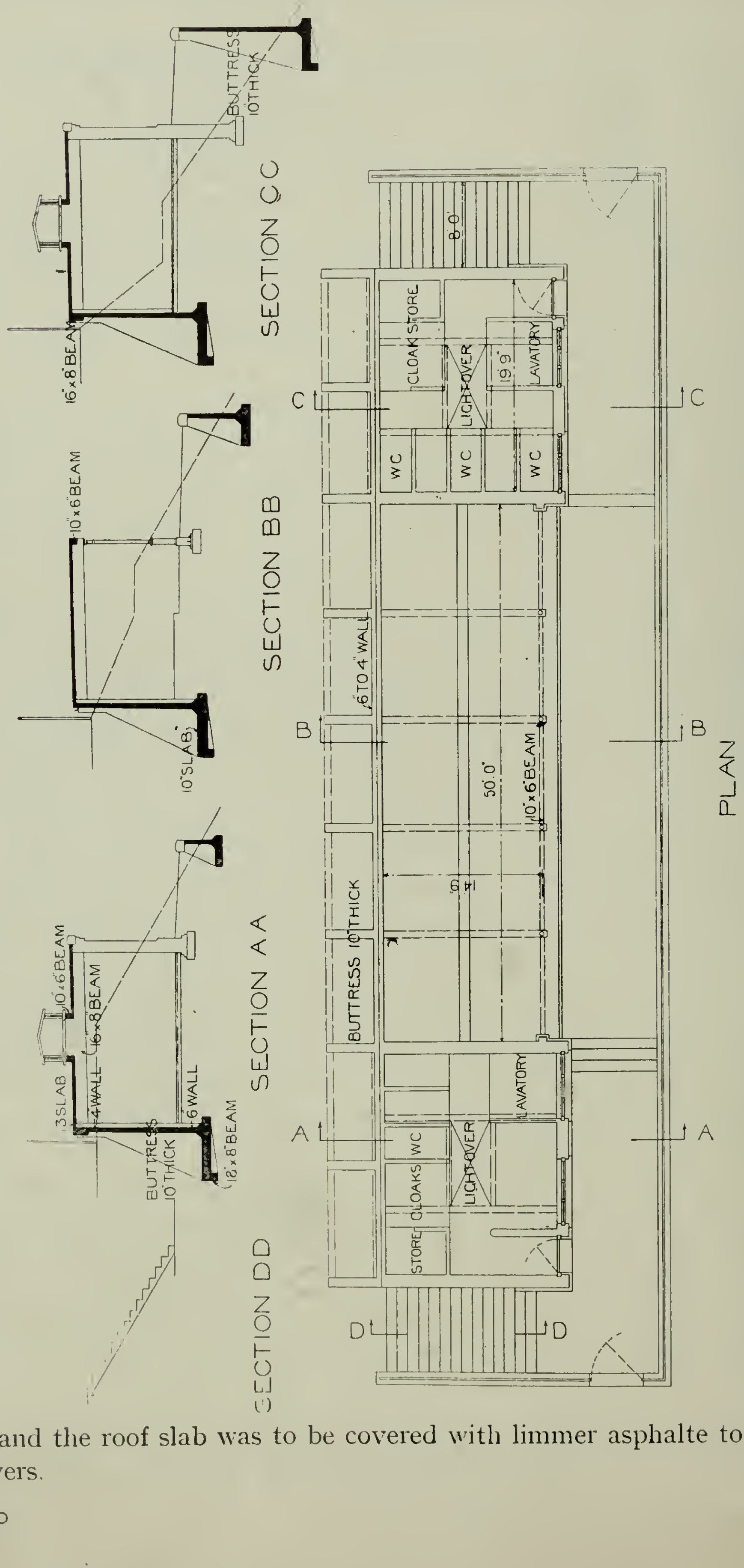
Running parallel with this wall, but about 28 ft. further seaward, and at a lower level, is another retaining wall built in reinforced concrete. This is also 13 ft. in height, and is built in a similar manner to the previous wall, being also strengthened by buttresses. The lower retaining wall is returned at the ends. Connecting the two retaining walls are 10 in. by 8 in. reinforced concrete beams or ties, placed at 10 ft. centres.

The roof slab is supported by 16 in. by 8 in. reinforced concrete beams These are spaced at 10-ft. centres. The roof slab is 4 in. in thickness, and has a fall from front to back, where it drains on to a channel formed in the concrete. This channel is connected to fall pipes which discharge on to gullies.

A moulded beam runs the entire length of the shelter. Reinforced concrete sills are placed around the openings for the lantern lights. Two flights of steps, each 8 ft. in width, are also constructed in reinforced concrete.

The concrete was specified to be formed of 3 parts of sea gravel to be capable of passing through a 1-in. ring, 2 parts clean sharp sand, and 1 part of best Portland cement. The steel to be of British manufacture, and guaranteed to withstand a tensile strain of 60,000 lb. per sq. in.

In no case was the steel to come nearer to the surface of the concrete than 1½ in., and the roof slab was to be covered with limmer asphalte to be put on in two layers.



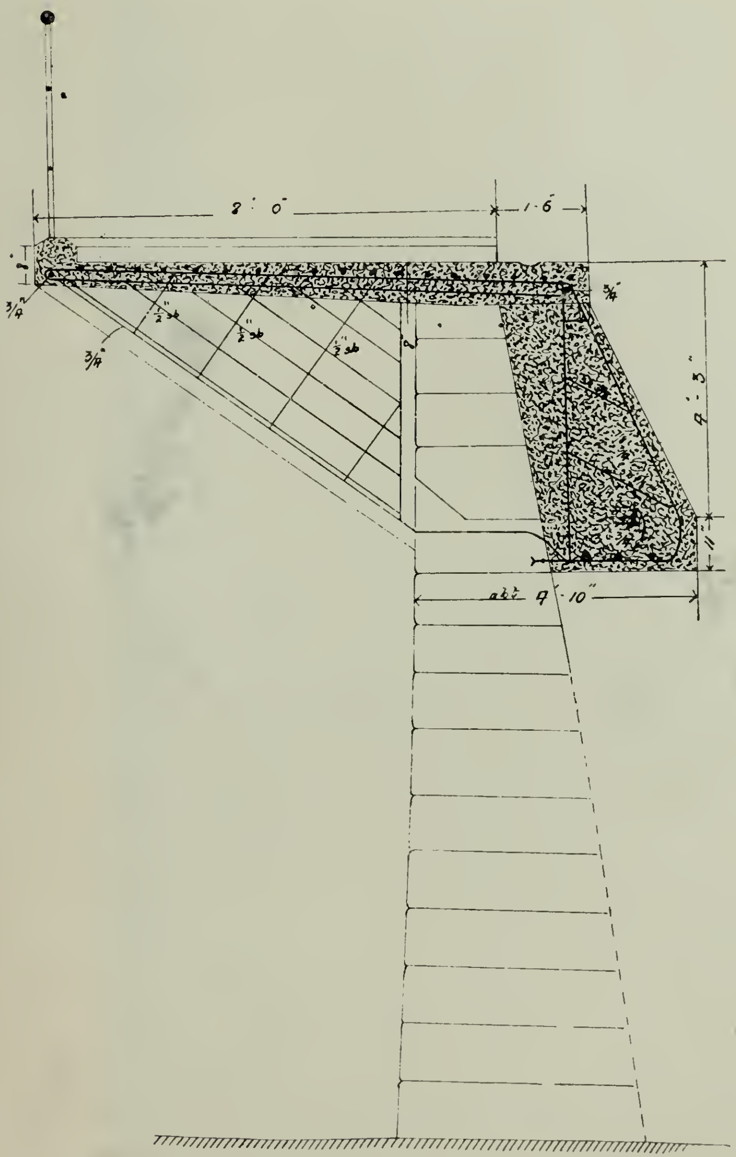
Plan and Sections.

Reinforced Concrete Lavatories and Public Shelter, Bridlington.

All steel was to be washed with cement grout at least 48 hours before being used. The steps were to have patent non-slip carborundum finish to treads.

The author estimates that quite 30 per cent. in the cost has been saved by the use of reinforced concrete; not only so, but it would have been a very awkward matter to have constructed the retaining walls in plain concrete, masonry, or brickwork, as the walls have to be built on the sloping face of a cliff, and heavy walls should certainly be avoided.

Reinforced concrete lends itself admirably to work of this kind, as the walls can be constructed with about one-third of the material, and consequently are only one-third of the weight of heavy masonry or brick walls.



Section of Reinforced Concrete Fish Stand.

Reinforced Concrete Work at Bridlington.

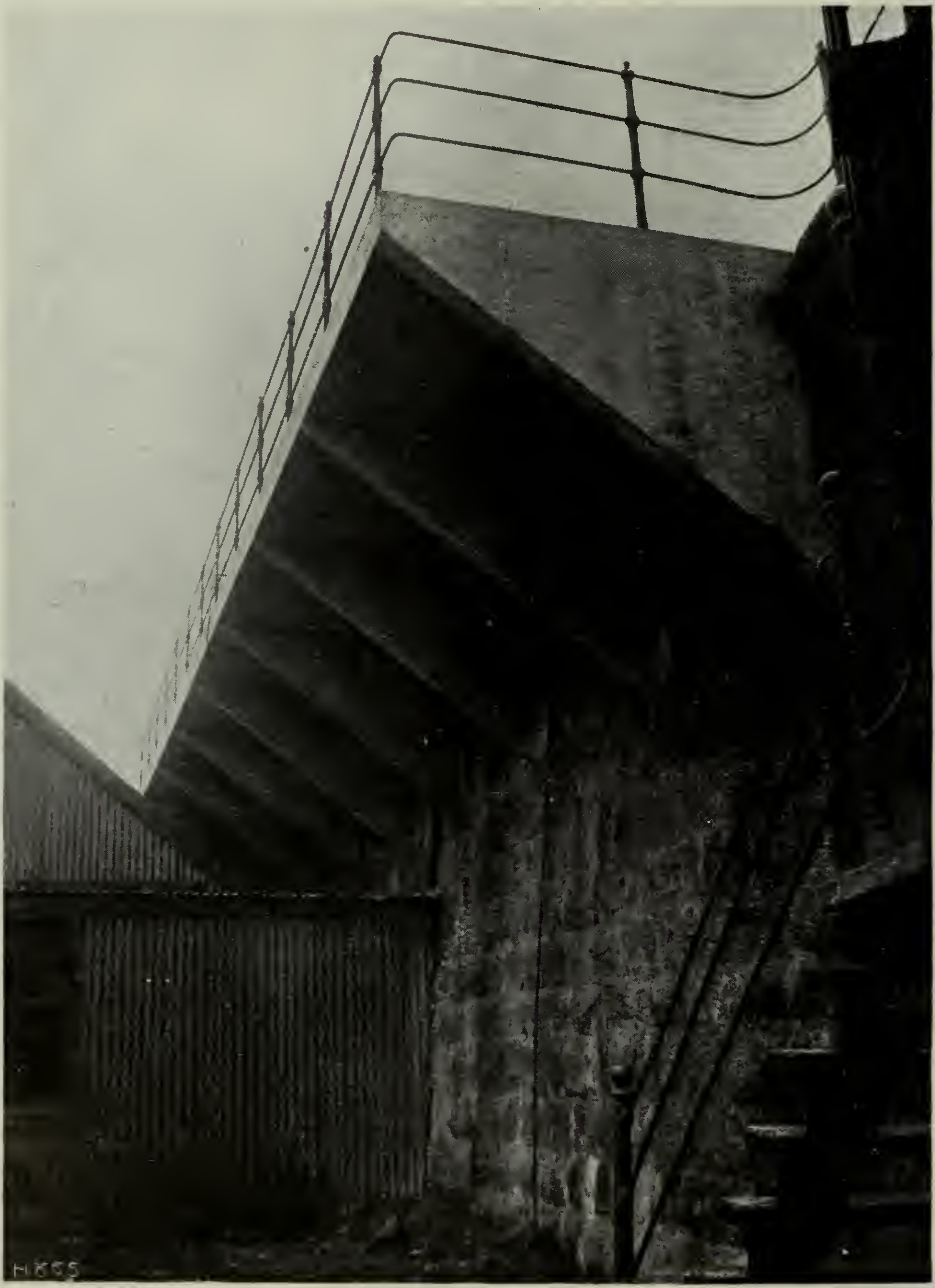
REINFORCED CONCRETE FISH STAND.

A very interesting piece of reinforced concrete work has just been completed at Bridlington; this is a cantilever platform which is carried out from a retaining wall at the north end of the harbour, and is being used as a fish stand. It was a somewhat awkward piece of engineering work, for the old retaining wall had been badly built, and the concrete backing used in its construction was of a very poor quality.

In order to put as little stress as possible upon the wall, it was decided to construct a mass concrete wall at the back of same for a depth of about 5 ft. below the road level, and to carry out from this a reinforced concrete slab projecting 8 ft., and supported by brackets which are 5 in. in thickness, and spaced at 6 ft. 2 in. centres. The brackets and slab are of 4 to 1 concrete, the mass concrete wall being of 6 to 1. The slab diminishes in thickness from 8 in. to 4 in.

The platform is 50 ft. in length, iron railings surround it, and the aggregate for the concrete consisted of fine sea gravel capable of passing through a $\frac{3}{4}$-in. ring, and sea sand.

The work was executed to the author's entire satisfaction by the Chain Concrete Syndicate, of Leeds; the reinforcement consisted of $\frac{3}{4}$-in., $\frac{7}{16}$-in., and $\frac{1}{2}$-in. rods, and special clips which are the patent of the firm named.



View of Underside of Reinforced Concrete Fish Stand.
REINFORCED CONCRETE WORK AT BRIDLINGTON.

On the completion of the work in December last a test load of $1\frac{1}{2}$ cwt. per sq. ft. was applied at the two end bays, and the deflection caused by the load was scarcely perceptible.

This is an example of the use of reinforced concrete in work of a somewhat unusual character. It is doubtful if any other material would have made so satisfactory a job.

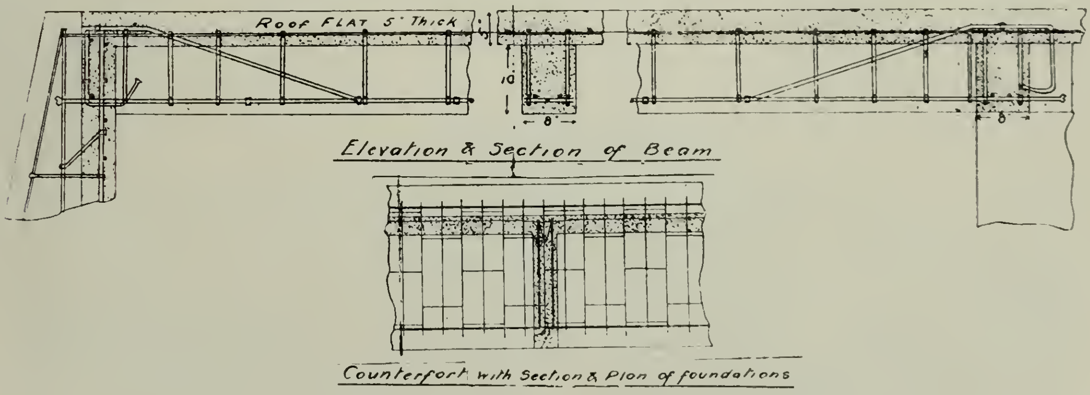
The contract price for this work was £114 12s. 6d. To this, however, must be added the cost of excavation and of the iron railings and fixing, bringing the total cost up to about £135.

For street-widening purposes, where a road is supported on one side by a heavy retaining wall, and it is necessary to widen such a road on that side, the author does not know of a better method than that adopted by him in this particular case, and it will be understood that if a large amount of such work is to be done, the relative cost per lineal yard will come out at a much less figure than in the case of this cantilever platform.

BEACONSFIELD LAVATORIES.

The reinforced concrete work at the New Beaconsfield Lavatories, at Bridlington, consists of reinforced concrete retaining walls and flat roof, the latter being supported by reinforced concrete beams. This work was completed a few months ago by the Chain Concrete Syndicate, of Leeds, and may be briefly described as follows.

On two sides of the lavatories a reinforced concrete wall has been constructed, the height of which is about 14 ft. This is strengthened by counterforts 5 in. in thickness, placed at intervals, and the roof is covered with two layers of limmer asphalte ; 10-in. by 8-in. reinforced concrete beams support the roof, and this is designed to carry a load of 1½ cwt. per sq. ft. irrespective of its own weight. The thickness of the roof slab is 5 in. The public promenade over this roof daily.


Roof FLAT 5" Thick
10
8"
8"
Elevation & Section of Beam
Counterfort with Section & Plan of foundations

Beaconsfield Lavatories.

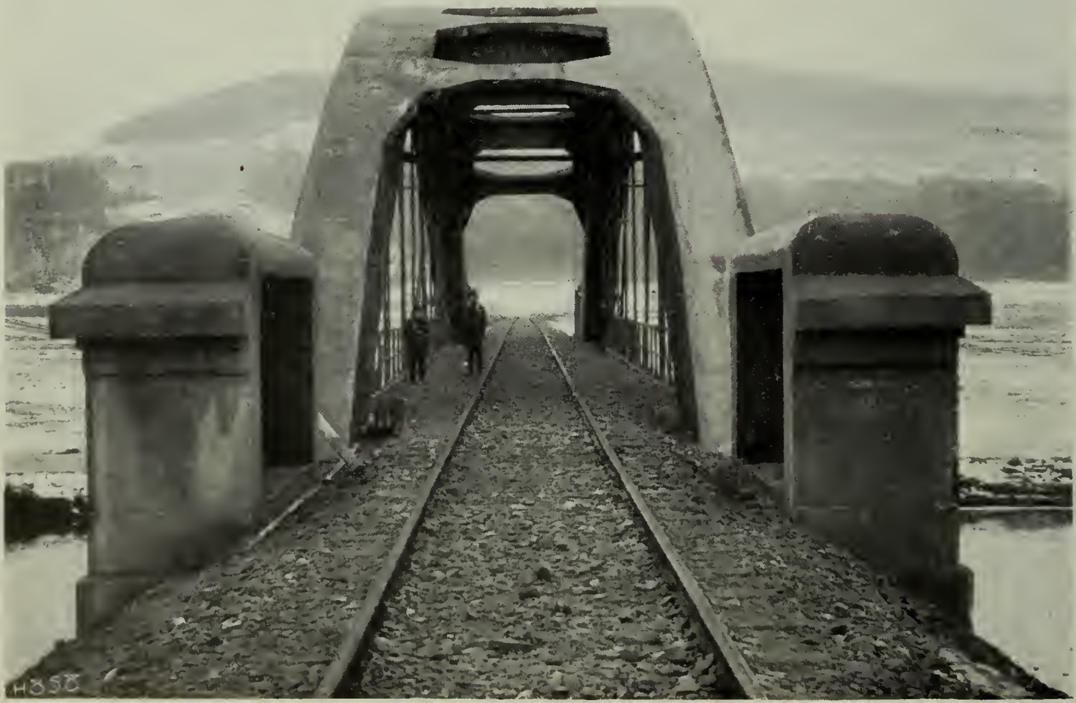
The underside of the roof is finished off with superfine Parian cement, and presents a very pleasing appearance, all angles in beams being chamfered.

The author considers that quite 25 per cent. in the cost was saved by using reinforced concrete.

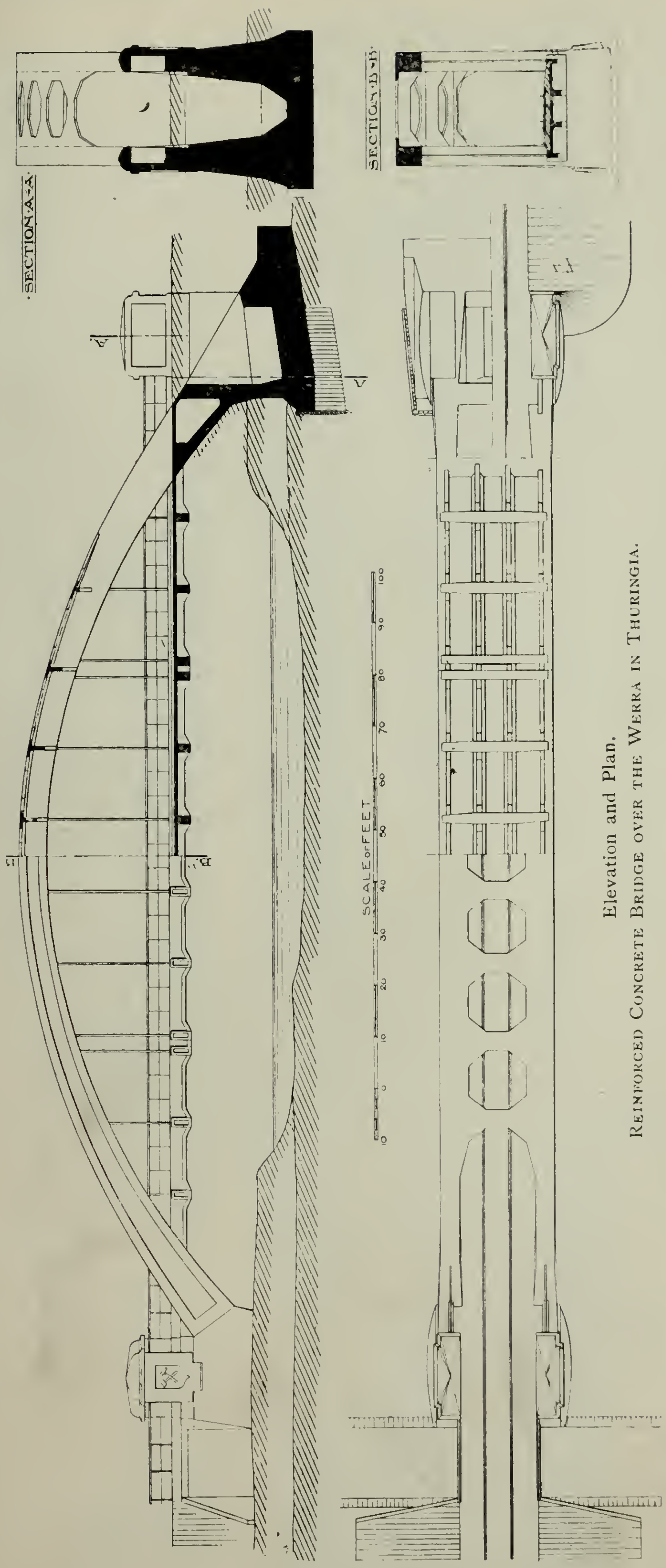
REINFORCED CONCRETE BRIDGE OVER THE WERRA, IN THURINGIA, GERMANY.

The bridge described in this article is one of the many highly interesting bridges of large span which have been carried out in reinforced concrete in Germany.—ED.

An address dealing with reinforced concrete railway bridges, delivered by Mr. Rud. Christiani to the meeting of the German Association of Architects and Engineers at Hamburg, contains, among others, a description of a bridge recently built by Messrs. Christiani and Nielsen over the River Werra, near Heringen Station on the Gerstungen-Wacha line in Thuringia. A branch line has been constructed, connecting two works for the extraction of potash salts, known as the Heringen



Reinforced Concrete Bridge over the Werra in Thuringia.

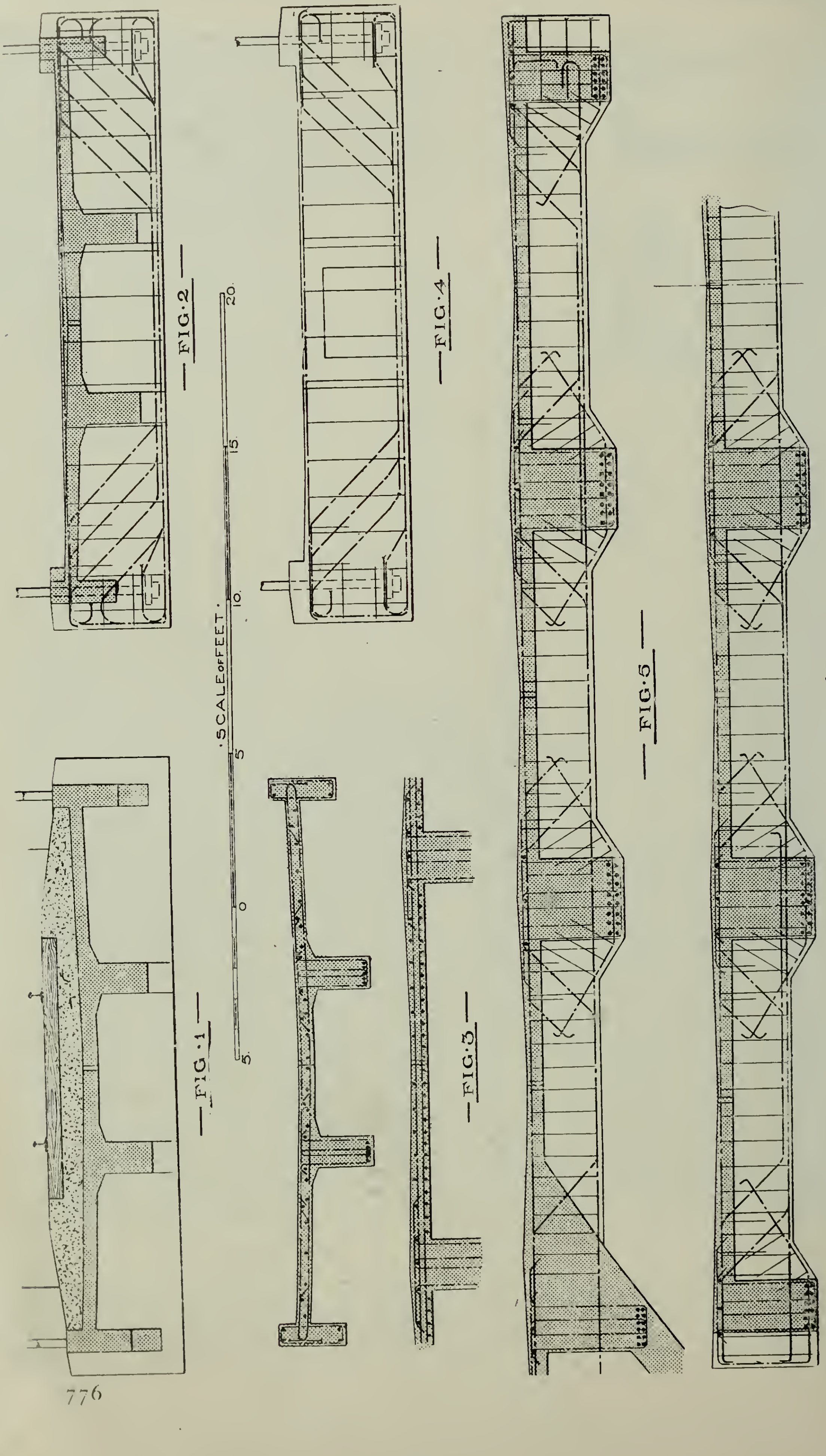


Elevation and Plan.
Reinforced Concrete Bridge over the Werra in Thuringia.

and Wintershall works respectively. The line is carried on earthen embankments, and has to cross the river at a point necessitating a clear span of 53 metres (173 ft. 11 in.). The depth of the river is 2 metres (6 ft. 6 in.) at low water and 5·2 metres (17 ft.) at high water, whilst the river authorities insist on a clearance of 6 ft. 6 in. above high water mark. The soil is a coarse, angular gravel, capable of carrying 2·5—3 kilog. per cm^2 (35—43 lb. per sq. in.) with safety.

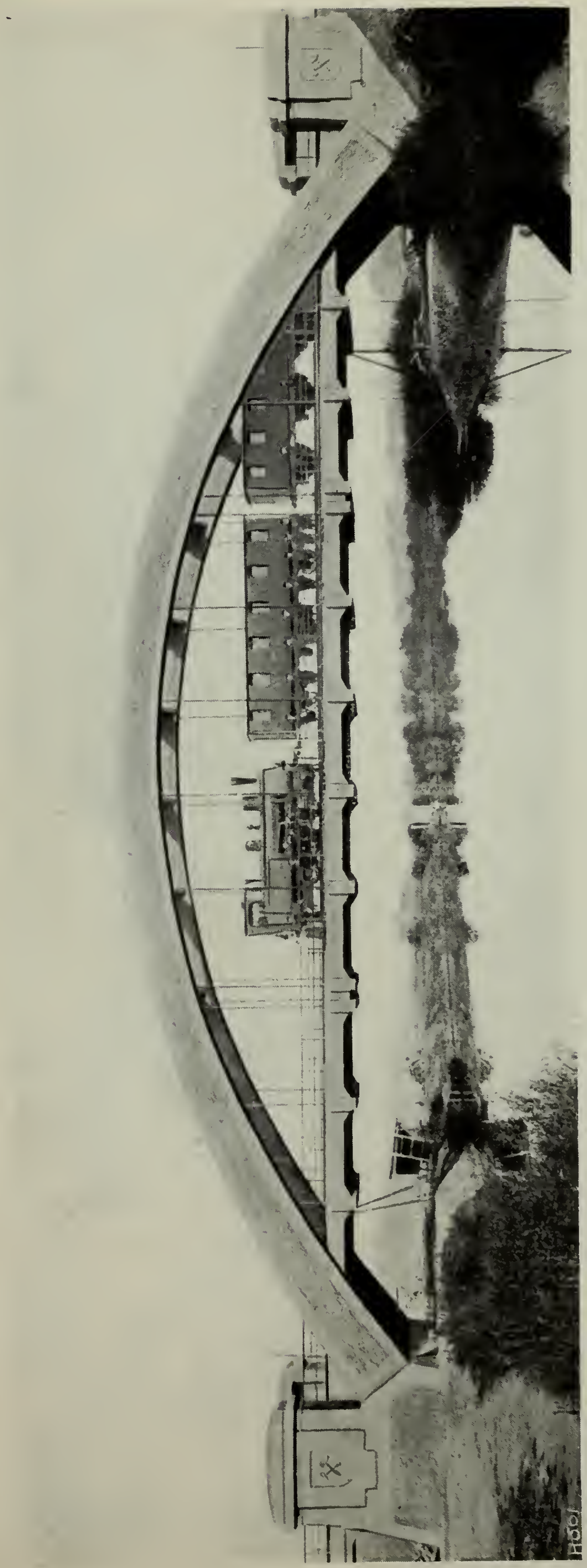
The design is that of a rigid arch, which the author prefers to any form of hinged arch, on account of the greater facility of construction and greater stiffness in all directions, in spite of the initial difficulties of the computation. The two arched beams are united above by transverse struts, and carry the reinforced concrete roadway by means of steel ties.

Provision is made against injury from variations of temperature by dividing the road into three parts, the two end sections being rigidly connected with the arched beams, whilst the middle section hangs freely, and engages with the end sections by means of indentations. The architectural effect would have



Details of Beams.

Reinforced Concrete Bridge over the Werra in Thuringia.



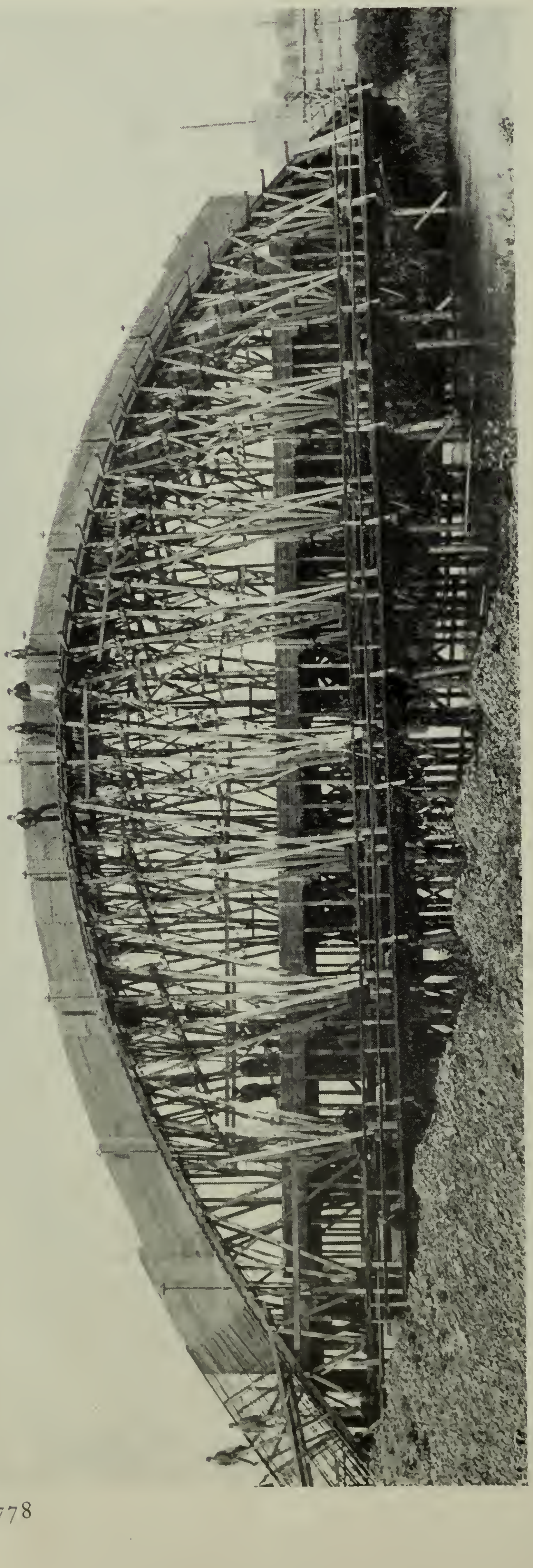
View of Finished Bridge.

Reinforced Concrete Bridge over the Werra in Thuringia.

been better had the vertical ties been of reinforced concrete instead of steel, but it was thought that the movement of the suspended road under the influence of changes of temperature would, by causing bending of the ties, set up severe bending stresses, and probably cause cracks.

The decking is 12 to 14 cm. ($5\frac{1}{2}$ in.) thick, and is carried by four longitudinal beams, which in their turn rest on transverse supports at intervals of 4·15 metres (13 ft. 7 in.). These supports are 80 cm. (2 ft. 7 in.) wide in the middle, tapering to 50 cm. (1 ft. $7\frac{1}{2}$ in.) at the ends. The rails are continuous, and are carried on sleepers which are readily removed sideways if required. The gravel ballast is 30 to 40 cm. (12 to 16 in.) deep.

The centering used in the construction of this bridge is of an interesting kind. It was parabolic in form, with a maximum excess of height in the centre of 50 mm. (2 in.) diminishing towards the ends. The supports rested on wedges, which could be removed when required, the central wedges being the first to be driven out. It was found that the settlement of the centering during the concreting amounted to 35 mm.



View of Arch in Course of Construction.
REINFORCED CONCRETE BRIDGE OVER THE WERRA IN THURINGIA.

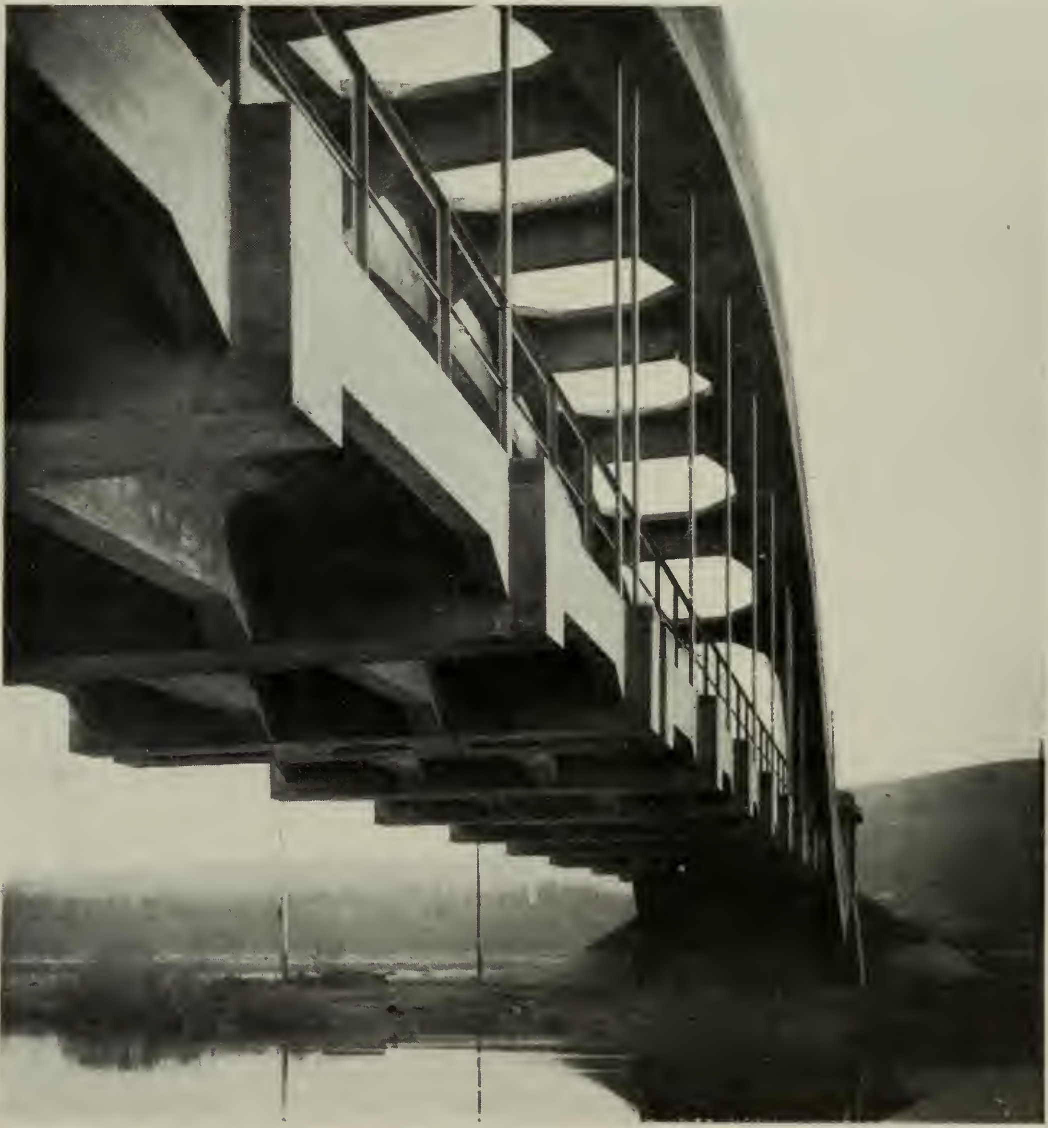
(1$\frac{3}{8}$ in.) at the crown of the arch, and when the centering was removed after the concrete had hardened for 5 weeks a further settlement of 11 mm. ($\frac{7}{16}$ in.) took place. The concreting of the arches was naturally performed before that of the roadway, but the reverse order was followed in the removal of the falsework, in order to avoid undue stresses in the vertical ties. The work was begun on April 15, 1910, and the concreting was finished on August 1 of the same year.

The clear span of 53 metres (173 ft. 11 in.) is the largest in Germany, and special interest therefore attaches to the loading tests conducted on behalf of the railway authorities on January 20, 1911. Three railway trucks, weighing about 48 tons each when loaded with potash salts, and a locomotive weighing 34 tons, were used for loading. Five different cases were examined :

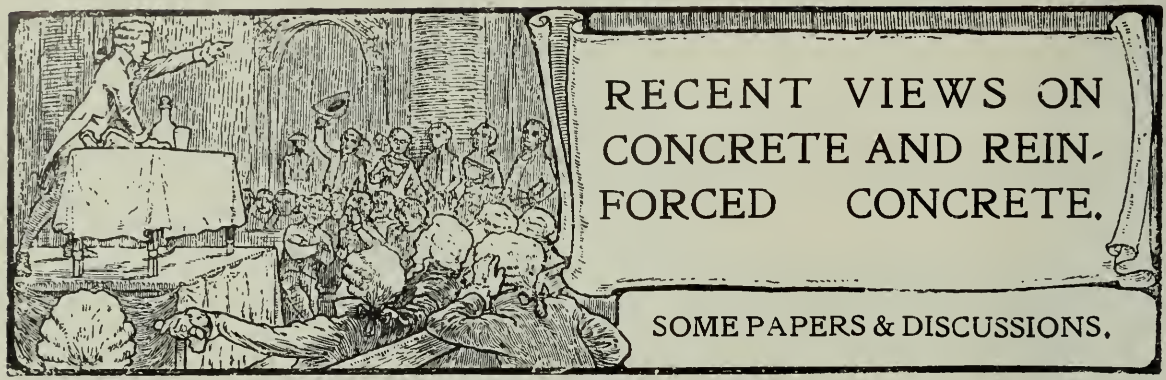
(1) Three trucks placed symmetrically in the middle of the bridge ;

(2) Two trucks, standing at the point at which the roadway is divided; (3) The same, at the other end; (4) One truck in the middle; (5) The whole train crossing the bridge at full speed.

The deflections were measured at twelve different points by means of wooden levers magnifying five times. The results show a remarkably close agreement between the calculated and observed deflections in all points, proving the possibility of computing correctly structures of this type. The results indicate a modulus of elasticity of 300,000 kilog. per sq. cm. (1,904 tons per sq. in.), which is double that usually assumed in calculation. It must be remembered, however, that the concrete was five months old, and of specially good quality, being a 1 : 6 mixture of natural ballast from the Werra river with cement. Cubes of the same mixture, tested in the Berlin Testing Bureau, gave a crushing strength of 365 kilog. per sq. cm. (5,190 lb. per sq. in.) after 28 days.



View from Underneath.
Reinforced Concrete Bridge over the Werra in Thuringia.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

BOSTON SOCIETY OF CIVIL ENGINEERS.

METHODS USED IN OBTAINING CONCRETE OF MAXIMUM DENSITY FOR THE WESTERLY STANDPIPE.

By Mr. ANGUS B. MACMILLAN.

The following paper was recently read by Mr. Angus B. MacMillan, Engineer of the Aberthaw Contruction Co., before the Boston Society of Civil Engineers. A description of the construction of the Westerly Water Tower appeared in our issue of June, 1911.

It was determined at the very start of the building of the Westerly Water Tower that we should depend on a very dense mix of concrete to insure water tightness, and in order to attain this result a large number of tests were made to discover the proper mixture for obtaining the maximum density with the aggregate at the disposal of the builders, and then to insure every batch of cement being as nearly as possible of the predetermined density. The first step was to make mechanical tests of the sand and stone available.

Two sizes of sand were tried : one a bank sand of the size commonly known as paving gravel and called No. 4½, and the other a fine bank sand known as No. 5. Crushed grey Westerly granite of all sizes between ½ in. and 1½ in., as screened at the crusher, was the stone used on this work. For testing purposes 100 ounces of material were used at a time. Samples were selected from the pile by quartering in order to get as nearly as possible average results. As the screens were not calibrated, values from Taylor & Thompson were used. The first sample of stone, known as No. 4½, gave the following results, the weights given being in all cases the amounts retained on the screen :

Sand No. 4½.

Size. Inches.		Percentage retained.	Size. Inches.		Percentage retained.
1	...	1½	8	...	39
¾	...	5½	20	...	62
½	...	15½	30	...	81½
⅜	...	20	50	...	95
¼	...	26½	100	...	98
$\frac{3}{16}$	...	31	200	...	100
⅛	...	33			

The fine sand, known as No. 5, when screened gave the following results :

SAND NO. 5.

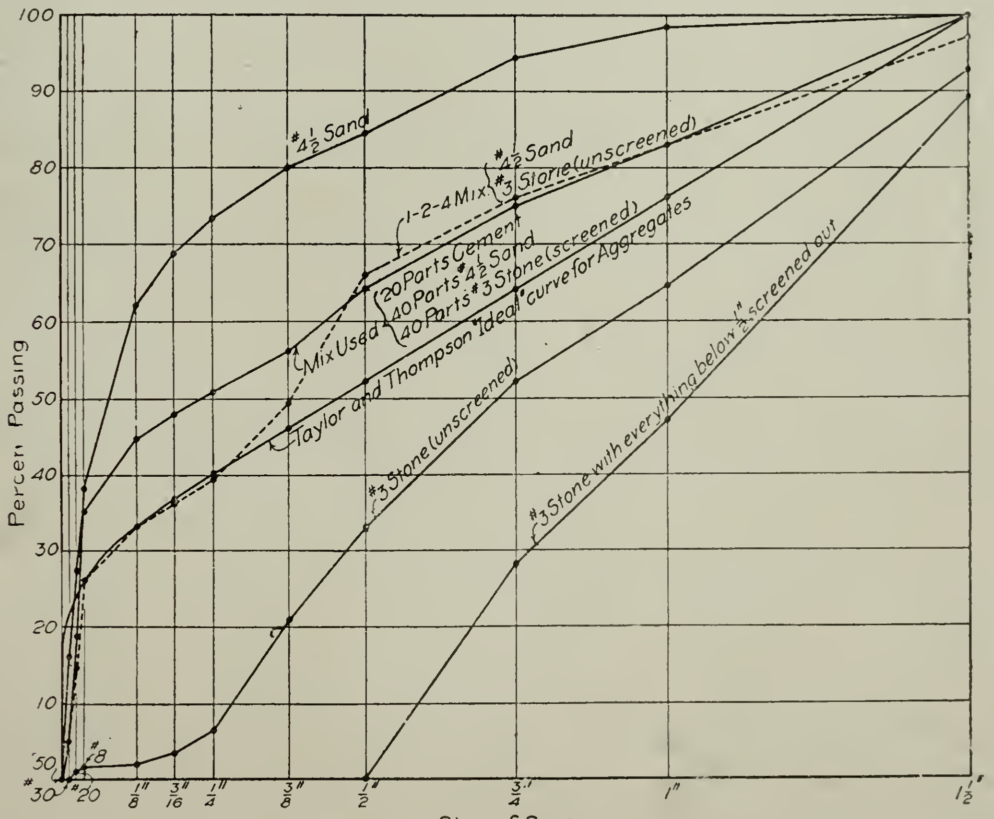
Size. Inches.	Percentage retained.	Size. Inches.	Percentage retained.
⅓	2½	20	37
⅜	5½	30	63
¼	9½	50	91½
3/16	12½	100	97
⅛	17	200	99½
8	18½		

The fine sand (No. 5) did not seem, however, to be as good quality as the coarse sand, there being a considerable amount of dirt in it, so that it was decided not to use this. Three samples of stone were then tested, and of these the results obtained with No. 3, the one used, are given below :

SAND NO. 3.

Size. Inches.	Percentage retained.	Size. Inches.	Percentage retained.
1½	7¼	3/16	96½
1	35½	⅛	98
¾	48	20	98½
½	57	30	99
⅜	79	50	100
¼	93½		

This stone (No. 3) was used with the coarse sand (No. 4½) and Portland cement in the proportion of 1 part cement, 2 parts sand, and 4 parts stone, and tested. The curve obtained by this combination is shown by the *dotted line* on the chart. It was obvious that No. 3 stone and No. 4½ sand as they stood could not be combined into a good curve. It did seem possible, however, to modify this by screening, and after



CURVES FOR AGGREGATE USED FOR WESTERLY STANDPIPE.

careful consideration it was decided to remove from the stone everything that would pass a half-inch screen. This screening was done by hand on a small screen. A second trial was then made using a mixture of 16·9 parts Portland cement and 26·7 parts sand and 53·5 parts of stone by weight. This mixture gave a curve that was practically coincident with the "Ideal" curve recommended by Taylor & Thompson. Trials for density were then conducted.

For this purpose a cylindrical can made of riveted $\frac{7}{16}$-in. steel plate was used. This can was 10 in. in diameter, and 15 in. in depth; 50 lb. of material was mixed in a metal box by hand, and enough water was then added to make a mix that would barely quake when mixed. The concrete thus formed was then transferred to the cylindrical can, and the distance down from the top of the can to the top of the mixture was carefully measured. The densest mix obtained was found to measure 7 in. down from the top of the can, thus giving a total volume for the 50 lb. of concrete of 610 cu. in. It was also determined that a variation of $\frac{1}{8}$-in. in height of mixture in the can above the mark set by this densest concrete corresponded to a change in volume of 1·6 per cent., thus giving a handy means of comparing any trial mixture. The density tests showed that the mixture giving a curve most nearly approximate to the Taylor & Thompson "Ideal" gave an excess volume over the best mixture of 6·4 per cent., and it seemed also to be lacking in mortar.

It was then decided that the concrete should be mixed so rich as to make only 12 cu. ft. to a 4-bag batch. The latter result was finally obtained with a mixture of 20 parts by weight of cement, 40 parts of No. 4½ sand, and 40 parts of No. 3 stone screened to remove everything below ½-in. This mixture had the maximum density of any that was measured, and appeared to be satisfactory in other respects. The curve given by this mixture, however, on volumetric tests, was nearly 10 per cent. higher than the "Ideal" of Taylor & Thompson at the point of tangency. In an endeavour to get even greater accuracy, a can of smaller diameter than the first was made, and further tests conducted with this. Twenty-eight various mixtures were tried, using this small diameter can, but the mixture mentioned above still showed the best results of any tested, and it was accordingly decided to use this on the work.

Further tests were conducted for the purpose of ascertaining whether or not even greater density might be obtained by the addition of hydrated lime to the mixture. It was found that with the densest mix the addition of hydrated lime increased the volume almost directly in proportion to the amount of lime used, and therefore it was considered of little use to add lime to the concrete.

In the course of the actual work on the standpipe, volumetric tests were not made every time samples were analysed, but only when they varied 2 or more per cent. from those in use was the curve of the mixture worked out. As the sand and stone used were measured in wheelbarrows, the quantity was subject to an unavoidable variation of 2 or 3 per cent., so that it was believed to be an unnecessary refinement to carry the curves to any greater accuracy.

The amount of water added was given a great deal of consideration. It was found—I believe that a paper recently read by Mr. Chapman before the National Association of Cement Users, gave some data on this point—that the percentage of water added to concrete in mixing has a very marked effect upon its permeability, and that even very slight variations from the proper constituency gives much greater variations in permeability; that is, if too much water is added the resulting concrete is much less waterproof than one with the ideal amount of water. This ideal amount varies, however, for different mixtures of cement and aggregate, and the nearest approximation that can be made offhand is that enough water shall be added to make a mixture which under tamping shall show water at the surface and give what we call a dry quaking mix—that is, a mix that will not quake until it has been thoroughly tamped. With any given cement and aggregate, preliminary tests may readily be made to determine the proper amount of water to use in mixing. Once the amount which gives a dry quaking mix has been found it is simply a matter of adding this proportion of water to each batch of concrete.

In the actual mixing of the concrete on this job we followed a method somewhat different from our usual one. One-half of the stone was put in the mixer and some water. The mixer was then revolved for a minute or so, and the sand and cement and the rest of the stone and water were added. The concrete was then thoroughly mixed for a total time of about five minutes, when the mixture was dumped and hoisted up on to the tower.

The tests described were conducted by Mr. W. W. Clifford, of the Aberthaw Construction Co.

AMERICAN SOCIETY FOR TESTING MATERIALS.

PRACTICAL CEMENT TESTING.

By ERNEST B. McCREADY, Lehigh Valley Testing Laboratory, U.S.A.

The paper here presented was read before the American Society for Testing Materials, and claims attention as tersely putting forward points in connection with cement testing, which it would be well if they were more generally realised, particularly among the smaller cement users.

THE continued wonderful growth of the cement industry adds increasing emphasis to the necessity for a uniform standard of tests and a more general adherence thereto. The first has already been provided through the efforts of this Society and its co-workers. The realisation of the latter is, in some respects, still a long way off.

Uniformity in the grade and quality of the cement itself will never be possible. There will always be grades in cement just as there are grades in pig iron. The fact is not yet generally recognised that cement is not, like sugar and salt, a standard commodity of uniform value so long as it is unadulterated with some foreign material. Cement is more nearly comparable to the bread or cake or confection (to carry out the figure), and its quality depends as much on the kind and character of the raw materials as on the skill of the cook. What we need to know now is not so much whether the food is fit to eat, but rather which food is best suited to our needs. Our tests must do more than differentiate between that which is merely good and any that may be positively bad. Our aim for the future must be to give a correct value to the *grade* of material we are testing. This can only be done by treating each sample as every other sample is treated, so far as practicable, making the necessary variations only according to fixed rules.

The valuable work done by this Society in formulating, adopting and recommending for general use uniform methods of procedure in carrying out the more common tests on cement, have accomplished much towards this end. But while progress has undoubtedly been made in this direction, very much more remains to be done. Many differences of method still exist, and many testers cannot or will not recognise the necessity for a change.

In the conduct of a commercial laboratory probably more than in any other, these facts, and the desirability of uniform standards, are constantly being emphasised. The manufacturer has to contend with the notions and peculiarities of various engineers and consumers. The commercial laboratory has to do not only with these, but also with the idiosyncrasies of the manufacturer as well. The problem of harmonising these discordant elements is the one that must be faced and solved first of all. It is the purpose of this paper to point out only a few sources of difference and contention (or at least of misunderstanding) which might easily be avoided by the general acceptance of a common ground on which all parties are *willing* to stand.

It is probable that the question of tensile strength has to do, in some form, with more disputes concerning cements than any other test. Such differences are usually ascribed to that convenient scapegoat, the "personal equation," which, although it is often the source of decided differences, is by no means the most troublesome factor with which we have to deal at the present time. Many trials have shown that men working side by side do get closely agreeing results when the work is done with reasonable care and intelligence. It is equally true that results from different laboratories often disagree more than would seem to be possible on the same cement. A study of the reasons for such differences and the conditions which produce them is interesting.

There are probably not more than half a dozen laboratories in which there is any earnest, careful effort to carry out every operation in accordance with the directions adopted and promulgated by this Society. On the other hand, there are laboratories where absolutely no effort is made to conform to these requirements. And it is a fact that there are cement testers in competent charge who have never read over or even heard of these standard methods.

The reason for this state of affairs is not hard to find. The fact that any other brand of cement had reached a given strength in somebody's laboratory tests, makes it incumbent upon the sale agents of each new brand to show that their cement can do as well or even a little better. When some engineer reports that he has made some tests, and that he gets the best results on a cement whose strength is limited at seven days, and always specifies such cement, it immediately becomes the fashion for engineers, without further investigation, to write in their specifications a limit to the tensile strength, or else a specified minimum rate at which the cement shall harden, or both. Again, it is "up to" the manufacturer. He must prove by his own tests, at least, that his cement will do as it is told if he expects to bid under these specifications. So nothing matters but results. No mention is made of the methods or conditions under which the tests are made. Hence we have this state of affairs; in the laboratories of various manufacturers we find that "normal consistency," or its equivalent, means anything from a paste so wet that it can be stirred up and filled into the moulds with a spoon or knife, in less than a minute, to a paste almost or quite as dry as is commonly used with the Boehme hammer, and which is compacted in the moulds with wooden tampers or with an iron form and a hammer.

It is not surprising, then, to find that an application of the standard methods in treating these different brands results, on the one hand, in higher short-time tests than those obtained by the manufacturer, and consequently a smaller gain in strength as measured by percentage, while the same relative treatment applied to another brand gives results considerably lower than the strength claimed for it.

It is sometimes argued that it is not fair to treat all brands alike, and the reasons advanced seem plausible; *but,* the user makes no difference in his treatment of different brands, and, indeed, it would be impracticable to follow out the minute changes necessary to allow for the peculiarities of various brands. We must not lose sight of the fact that the object of testing cement is to get information as to its comparative behaviour under uniform conditions. We all know that our test methods are arbitrary. This has been said so often that it is becoming trite. But, until the recognised standard of measurement is changed by common consent to something better, it surely behoves us all to "measure by the stick."

In many laboratories the effect of temperature on the results is practically ignored, and in only a few is *any* attempt made to keep the temperature uniform. Any room that can be spared in any part of a building is often considered good enough for a laboratory. Not long since the tests on the cement for an important work were carried on by the inspector in a small closet without ventilation, and necessitating the use of artificial light continually. It is not necessary to add that the cement was often found to be quick-setting. In a cold laboratory, on the other hand, an actually quick-setting tendency, which might lead to serious trouble on the work, is likely to be overlooked.

Briquettes of different ages are often stored in different rooms. Frequently only those to be broken at seven and twenty-eight days are kept in a heated room, the longer-time briquettes being stored in a cellar or other convenient place—in water, which is seldom or never renewed, and taken therefrom at a temperature of perhaps 40° F., or less in winter time, and immediately broken. The results are recorded without comment, and at some later time are serenely compared and averaged with others broken, perhaps, in midsummer under exactly opposite conditions, and the *cement* gets all the credit or blame, as the case may be, according to the showing.

Occasionally laboratories, built for the special purpose—light-frame structures, perhaps, while otherwise well equipped and well suited for the purpose—are turned into veritable ovens in summer time by a low tin or rather flat roof.

The writer has several times been called upon to determine the reason for abnormal differences in the results of different laboratories. In one instance a chronic case of lack of gain, or else retrogression, at twenty-eight days was traced to a laboratory temperature which so hastened the hardening of the test pieces that practically the full ultimate tensile strength was developed at seven days or less, while the continued high temperature of 90° to 95° really produced before the end of twenty-eight days much the same effect as an accelerated test would have shown in a few hours. The hydration of any small quantity of uncombined lime present was hastened, causing a falling off in strength, which normally might not have appeared until a year or more later.

In another case in mind, a finely ground, slow-setting cement was rendered so much slower by a laboratory temperature of 50° F. and cold gauge water that the 24-hour briquettes showed only about half the strength required by specification; and, after six days' immersion in water at 60° or less, the strength was still below specification requirements, both neat and sand. The cement itself was perfectly normal, except in setting time as just noted, which was about seven hours under normal conditions.

These cases serve to illustrate the extremes, and all possible variations between, that are constantly being brought to the attention of the manufacturer and the commercial laboratory.

There is much more to be standardised than the mere manual procedure of testing. Engineers need to recognise the fact that it is unfair to pick out what they conceive to be the " good " points of several different brands and apply them as a measure to all brands which they may use. They should remember that high neat tests do not usually mean correspondingly high sand tests; that fine grinding is not often consistent with high neat tests; that because one laboratory reports a certain percentage gain on one brand is no reason why anyone should require the same gain from some other brand, and especially without inquiry as to the method of manufacture and testing which produced these results.

There is obviously a limit to the tensile strength of Portland cement, and the nearer this limit is approached at seven days, the less possibility remains for much gain thereafter. And no tests have ever shown that this fact of itself renders a cement less desirable than one whose seven-day strength is so low that it can gain largely up to twenty-eight days or longer. For most modern work the former would seem to be the more desirable cement. Any marked retrogression in either case is due largely, if not wholly to details in manufacture. In fact, it is the writer's experience that nearly all cements which at any time fall off to or below seven-day strength are those which are known to be unsound when tested or not properly burned, and this occurs most frequently with low-pulling, light-burned cements.

There is much room for education on the part of the cement user. He needs to know, first of all, what he really wants in a cement—that is, what properties are of special value in his work. With this knowledge will come a better realisation of the necessity, not only for uniform methods, but, what is more to the point, uniform tests. When he realises that, because one brand does not harden quite so rapidly as another, it is not necessarily inferior for the average piece of work, and that the cement which fails to gain 12 or 15 per cent. over 900 pounds from seven to twenty-eight days is not likely to suffer by comparison with average cements in any other way; that when properly made and seasoned these cements are equally good for most ordinary work (although one or the other may be superior for some special work); when these facts are generally understood and appreciated there will be no reason for a manufacturer to modify his test methods so as to make a given showing—to obtain predetermined results—and uniform tests will be advanced a long way, and the manufacturer will be the first to hail such a condition.

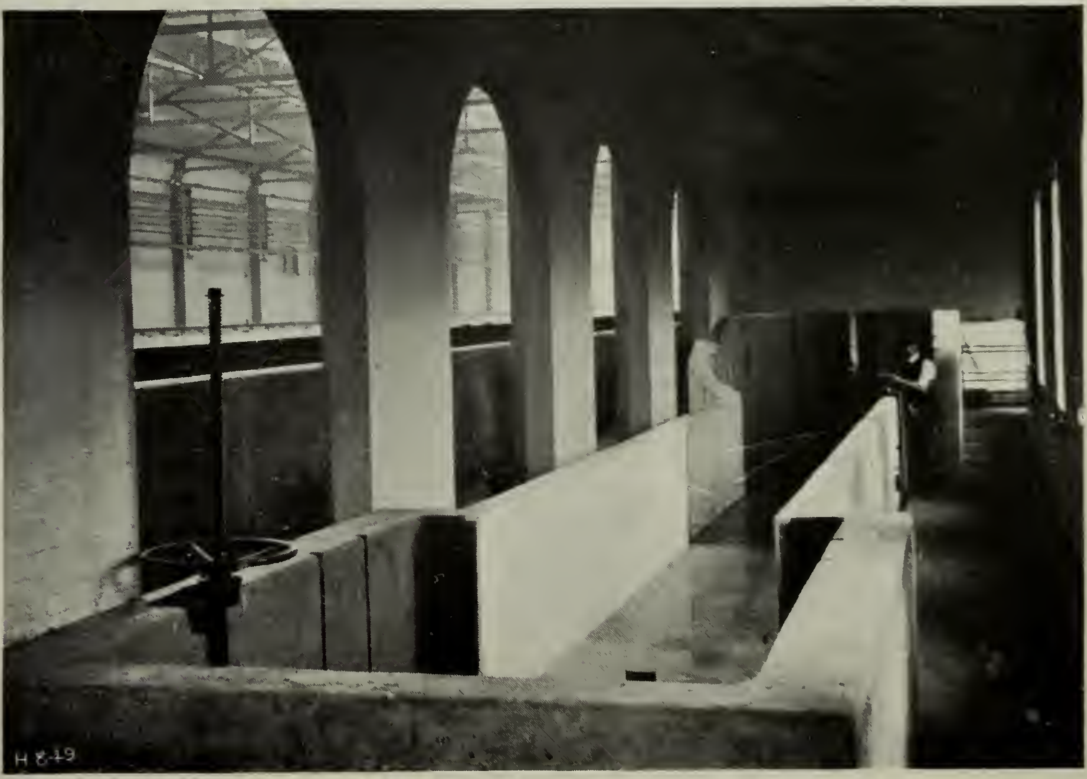
NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

EXPERIMENTAL TANKS AT THE NATIONAL PHYSICAL LABORATORY, TEDDINGTON.

THE experimental tank building at the National Physical Laboratory is now complete, and the special equipment well advanced. There are two water basins, the larger, constructed of concrete varying in thickness from 2 ft. to 4 ft. in places, is 550 ft. by 30 ft., and 12 ft. 3 in. deep. It is provided at the north end with docks for storage arranged to give easy access to the models, at the south end with a shelving beach to eliminate the waves formed by the models. The models used for experiments in this basin are of paraffin wax, and will vary in length from 14 to 20 ft., and will be towed from a carriage, electrically driven, which runs on rails secured on either side to the top of the tank walls. The final adjustment of the motors of this carriage will be completed shortly, and it is then hoped that a speed of 17 miles per hour will be obtainable over the steady portion of an experimental run of a model. The tank walls and floor are made of 6 to 1 Portland cement concrete. The walls are 2 ft. thick at the top, and have a batter of 1 in 8 both inside and out. The floor is 2 ft. thick generally, with a slope each side to the centre line. Walls and floors are keyed to one another, and the inside finished in a circular arc at the joint. The whole basin was built in lengths of about 40 ft., the floor first, and after a short interval the walls, and a dovetail gap of 6 in. to 10 in. was left between the sections to allow of any settling or shrinkage of the walls to take place without cracks developing in them. The joints between these sections were filled in after the walls had been



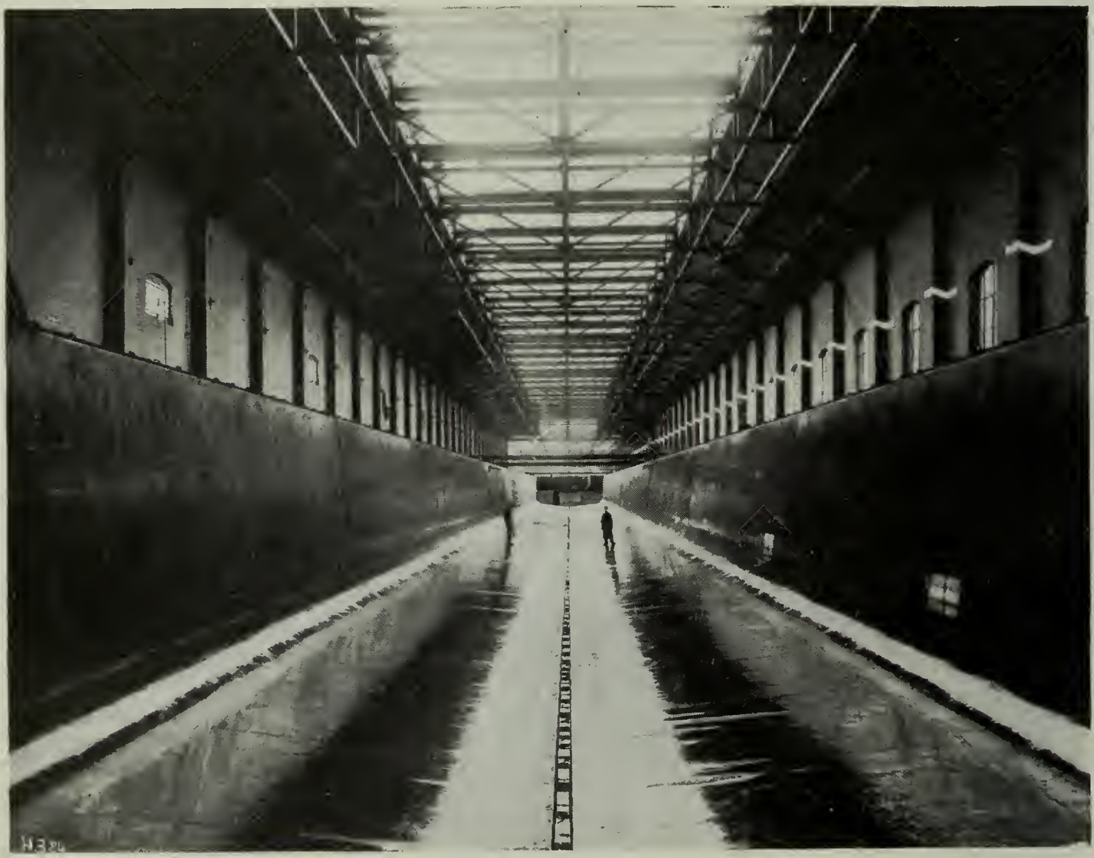
The small Reinforced Concrete Tank.

EXPERIMENTAL TANKS AT THE NATIONAL PHYSICAL LABORATORY, TEDDINGTON.

standing for about three months. A face-rendering of about 1 in. of cement was afterwards worked over the whole inside of the tank. The tank has been filled for several months and no visible crack of any sort has developed up to the present.

The small tank is 58 ft. by 5 ft. It is built of reinforced concrete, 7 in. thick, faced over 20 ft. of the central portion with iron plates.

A rotary pump is fixed in the tank at the north end, which will enable model experiments with flowing water to be made. For still-water experiments, pits 16 ft. deep have been constructed on the middle line at each end of the tank. The block of buildings for metallurgical laboratories is at present in course of erection. The new buildings adjoin, and will be continuous with the existing metallurgical chemistry laboratories ; the first four rooms constitute an extension of the chemical laboratories, and are similarly constructed. Beyond these is a two-storey block, 50 ft. by 100 ft., containing on the ground floor rooms for the preparation of micro-sections, for microscopic observation and photo-micrography, and a " museum " and specimen store.



The large Concrete Tank.

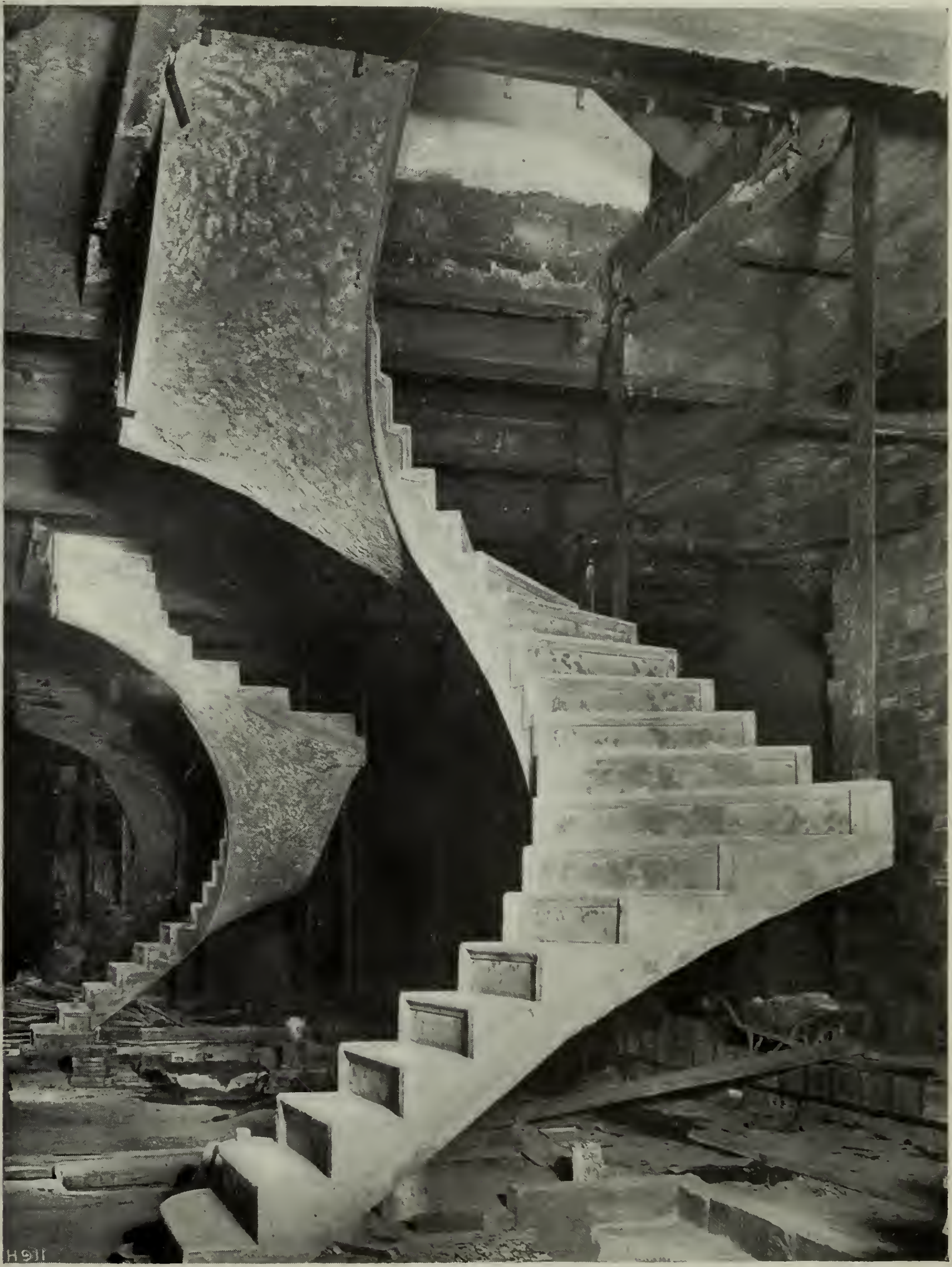
Experimental Tanks at the National Physical Laboratory, Teddington.

On the first floor are the offices of the superintendent and staff, rooms for small electric and small gas furnaces and a central pyrometer room, also a special " corrosion " laboratory, a large battery room, and store rooms. The floor and roof-flat of this building will be of reinforced concrete, and the whole will be fireproof.

REINFORCED CONCRETE STAIRCASES IN THE RITZ-CARLTON HOTEL, NEW YORK.

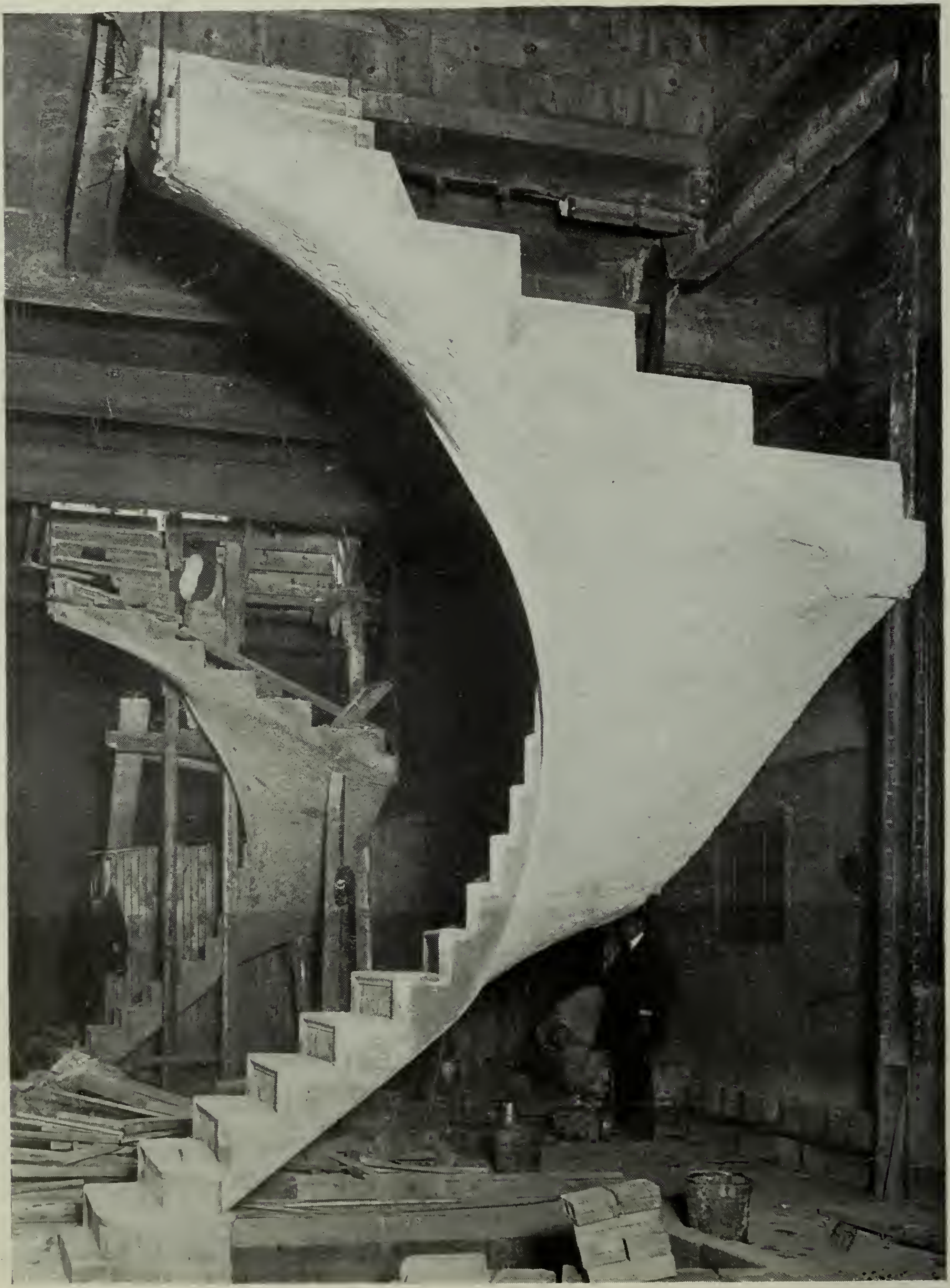
The spiral staircases of reinforced concrete at the Ritz-Carlton Hotel, New York, are shown on pages 789 and 790. Our contemporary, *Engineering Record*, from which these particulars are taken, mentions that they were erected to provide independent access to the four-storey apartments, which are a feature of the hotel.

These concrete staircases, which start at the cellar level, are of the ordinary straight design to the first-floor level, but from there to the top a special winding staircase is employed. Each staircase is supported at three points by iron hangers cast in the concrete and suspended from the floor beams above, which gives a beam construction with two end supports. Cantilever landings were used. Because of the warped surfaces the forms were extremely difficult to build. The soffit was moulded



Reinforced Concrete Staircases in the Ritz-Carlton Hotel, New York.

on a $\frac{3}{4}$-in. layer of 1 : 3 mortar applied to $\frac{1}{4}$-in. wire mesh, which was attached to transverse pieces. This mortar was allowed to take a hard set, after which the longitudinal and transverse reinforcement was wired in, and the final cast of a complete staircase made at one operation. The soffit was plastered in the upper storeys and basement, while in the cellar it was simply rubbed to give a finished appearance. No form was used for the treads, and the surface for the entire width



Reinforced Concrete Staircases in the Ritz-Carlton Hotel, New York.

of 3½ ft. was hard trowelled. All risers and exposed strings were rubbed until smooth the stairs were primed and enamelled.

The lower and upper ends of each staircase are supported directly on the floor and beam construction of the building.

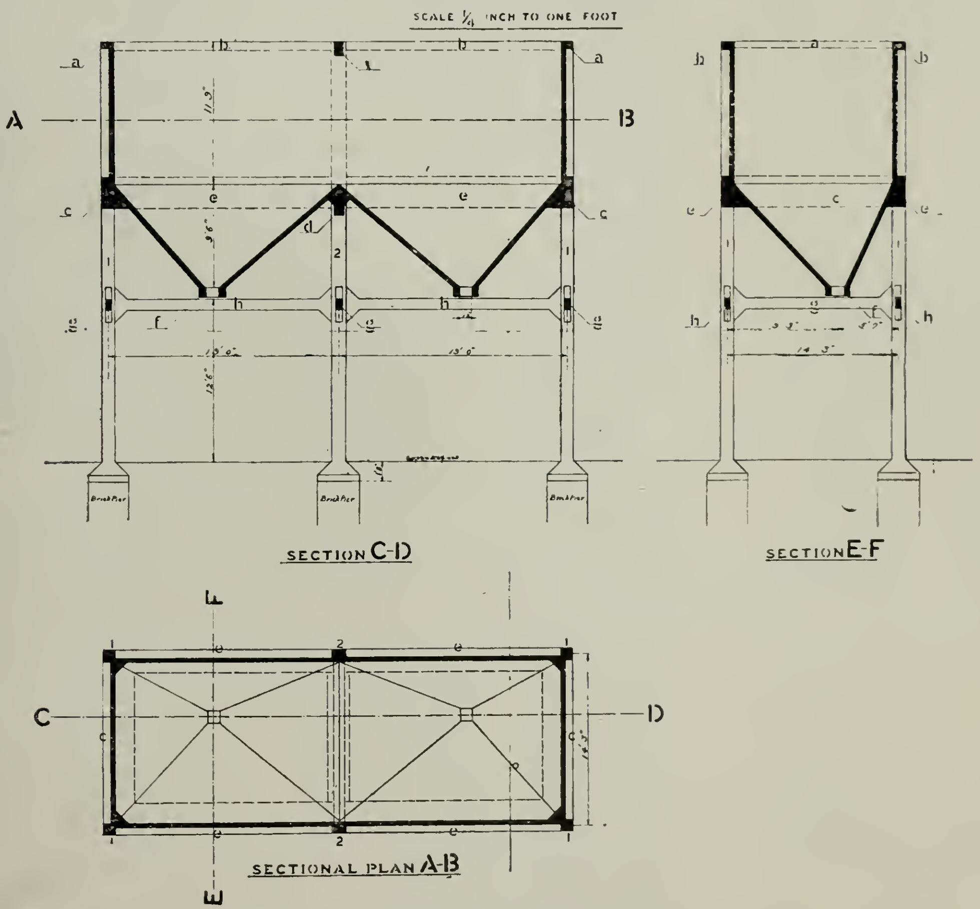
All reinforcement consisted of square cold-twisted steel bars, on which a unit tensile stress of 16,000 lb. per sq. in. was allowed. The longitudinal reinforcement consisted of $\frac{5}{16}$-in. square bars spaced 2¾ in. on centres on the two side sections of each staircase, and $\frac{5}{16}$-in. rods 10 in. on centres for the middle portion.

A 1 : 2 : 4 mixture of cement concrete poured at a medium wet consistency was used, and a unit compressive strength of 400 lb. per sq. in. was allowed.

The Turner Construction Co., of New York, were the contractors for all the reinforced concrete work in the building, including the staircase above described.

REINFORCED CONCRETE COAL BUNKERS AT LARNE, IRELAND.

Some coal bunkers have recently been erected on the Coignet system of reinforced concrete construction at Larne, in the north of Ireland, for the British Aluminium Co., Ltd., the contractors and licensees of the Coignet system being Messrs. The Irish Armoured Tubular Flooring Co., Ltd., of Belfast.



Plan and Sections.

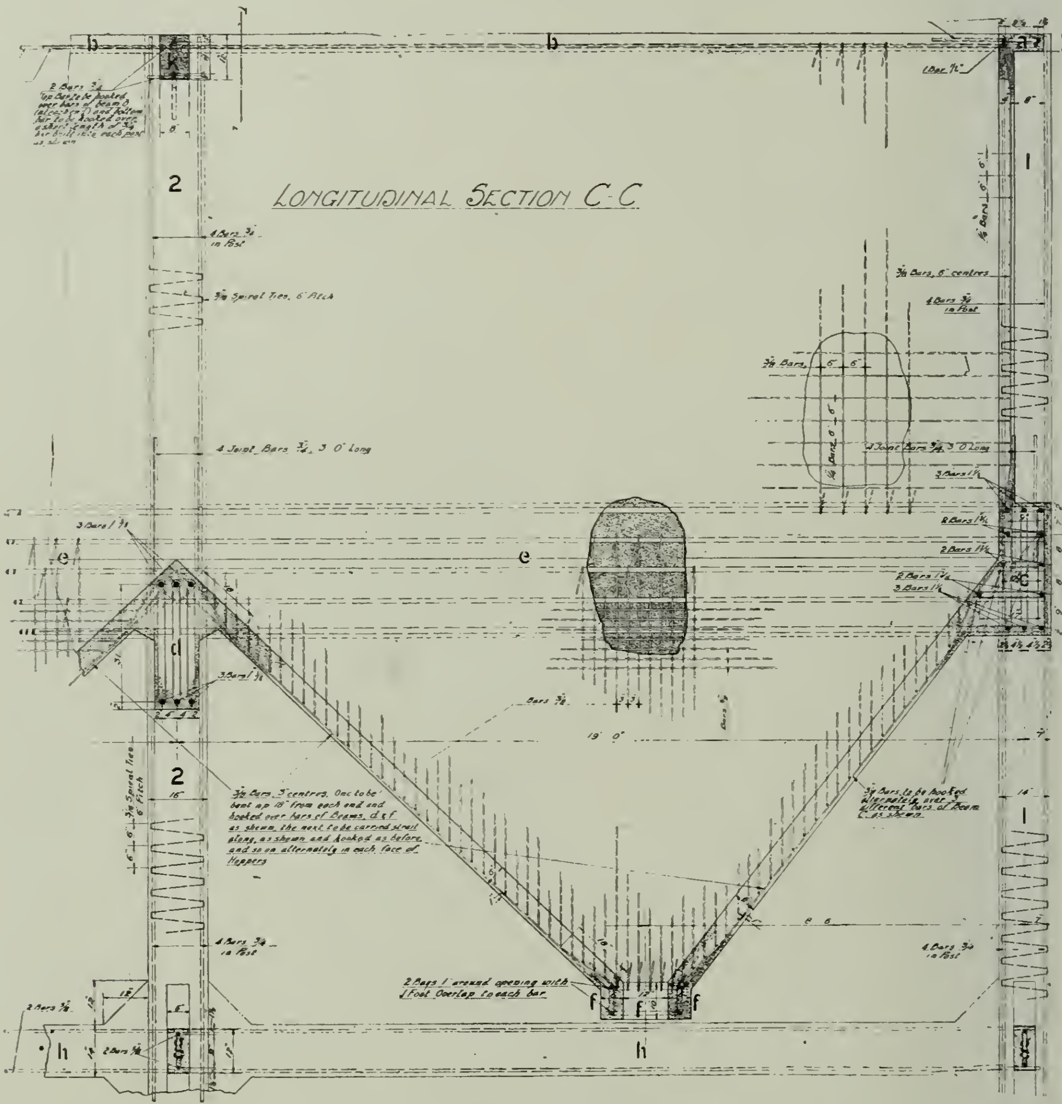
Reinforced Concrete Coal Bunkers at Larne, Ireland.

As shown in the accompanying plans, these coal bunkers are composed of two suspended hoppers in reinforced concrete. The total width of the structure is about 15 ft., and the length about 40 ft., with a total height of approximately 35 ft. The work is supported by six reinforced-concrete pillars braced together by means of beams.

The thickness of the upper panels is 4 in., and the thickness of the lower panels forming the hoppers is 6 in. Both contain a meshwork of bars, and the load is distributed from the panels on to the beams and posts.

The working drawings and the scheme were prepared by Messrs. Edmond Coignet, Ltd., reinforced concrete specialists, of 20 Victoria Street, S.W., under the instructions of the engineer of the British Aluminium Co.

The Coignet system has already been very extensively used by the British Aluminium Co. for their new works at Kinlochleven, where a series of enormous bunkers have been executed, and a large number of bunkers of various sizes. These works have already been described in one of our former numbers.


LONGITUDINAL SECTION C-C
b
b
a
2 Bars ¾
Top Bar to be hooked over bars of beam b (alternately) and bottom bar to be hooked over a short length of ¾ bar built into each post as shown
2
1
4 Bars ¾ in Post
⅜ Spiral Ties, 6" Pitch
4 Joint Bars ¾, 3' 0" Long
⅜ Bars, 6" centres
4 Bars ¾ in Post
⅜ Bars, 6" 6"
⅜ Bars 6" 6"
4 Joint Bars ¾, 3' 0" Long
3 Bars 1¼
2 Bars 1¼
2 Bars 1¼
2 Bars 1¼
3 Bars 1¼
c
1 Bar ½"
3 Bars 1⅛
e
e
d
3 Bars 1⅛
Bars ⅜
19' 0"
2
16"
⅜ Spiral Ties 6" Pitch
⅜ Bars 3" centres. One to be bent up 18" from each end and hooked over bars of Beams, d & f as shewn, the next to be carried strait along, as shewn and hooked as before and so on alternately in each face of Hoppers
⅜ Bars to be hooked alternately over different bars of Beam c as shewn
1
4 Bars ¾ in Post
4 Bars ¾ in Post
2 Bars 1" around opening with 1 Foot Overlap to each bar
f
f
f
2 Bars ⅜
2 Bars ⅜
h
h

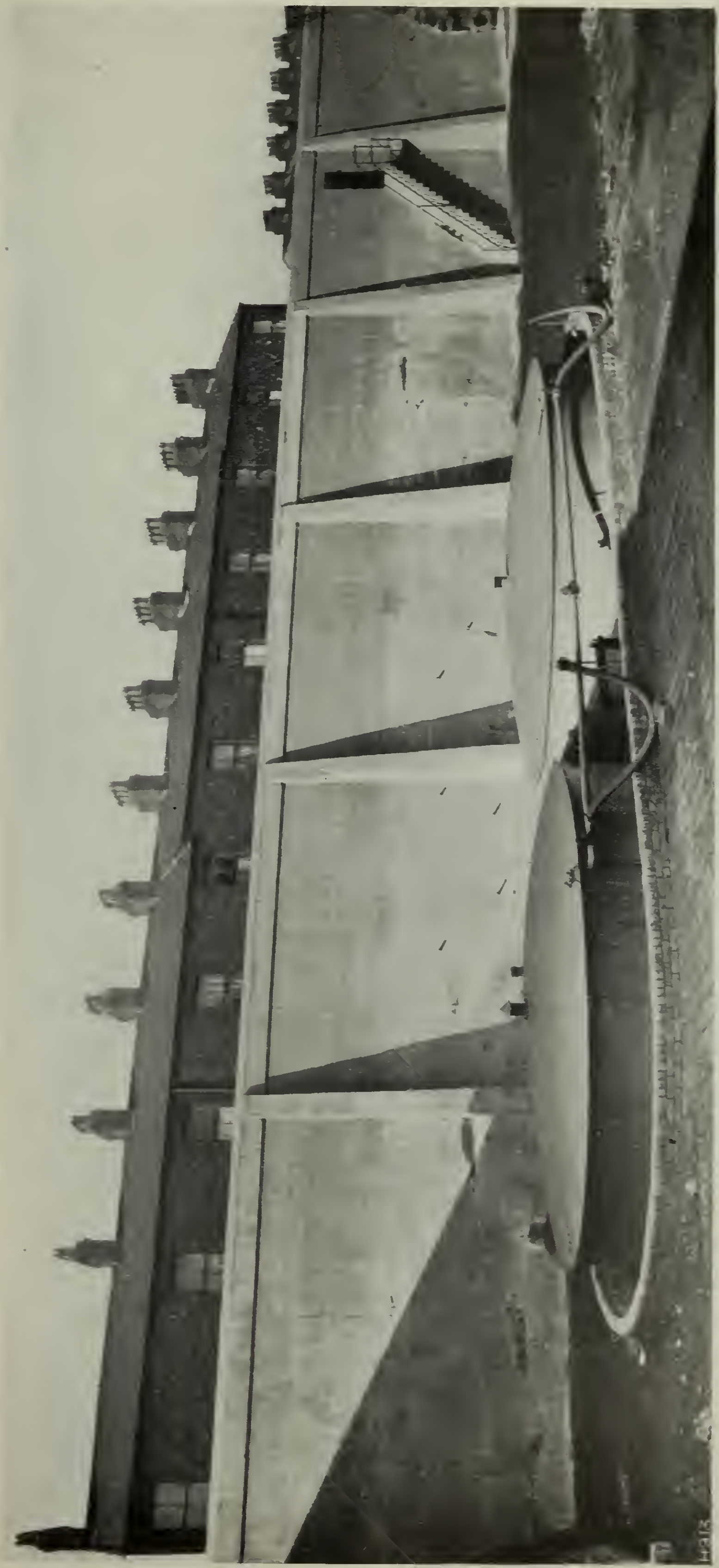
Longitudinal Section.

REINFORCED CONCRETE COAL BUNKERS AT LARNE, IRELAND.

REINFORCED CONCRETE RETAINING AND PARAPET WALL AT BIRKENHEAD CORPORATION GASWORKS.

THE wall shown in our illustration on page 793 has a total height of 27 ft. 6 in., and is 159 ft. long. It retains a depth of earth of 17 ft. 6 in., the upper 10 ft. of height acting as a parapet or boundary wall to a passage formed between the wall and the yards of existing cottages. Consequently, the wall sustains the combined load due to the earth and the pressure due to the existing buildings.

The retaining wall portion is 1 ft. 6 in. in thickness, and is reinforced with No. 2 rib-mesh Expanded Steel; the boundary wall portion is 6 in. in thickness, and is reinforced with No. 4 rib-mesh Expanded Steel. The lower portion of the wall has an additional layer of reinforcement, bent to radius, which serves to take up the bending moment at the heel, and it is further strengthened by two diagonal layers to take up the compression stresses at the same place.



Reinforced Concrete Retaining Wall at Birkenhead Corporation Gasworks.

The wall is buried in the soil to a depth of 4 ft. 6 in.; and the toe. which extends 1 ft. 6 in. below that level, and is provided to resist lateral movement, is also reinforced with No. 2 rib-mesh Expanded Steel.

The raking buttresses, 1 ft. 3 in. wide on face and spaced 10 ft. centre to centre, taper from the angle of the base at the bottom to meet the coping at the top.

A concrete staircase, reinforced with No. 8 diamond-mesh Expanded Steel, was built on the face of the wall to give access from the lower or yard level to the upper or passage level.

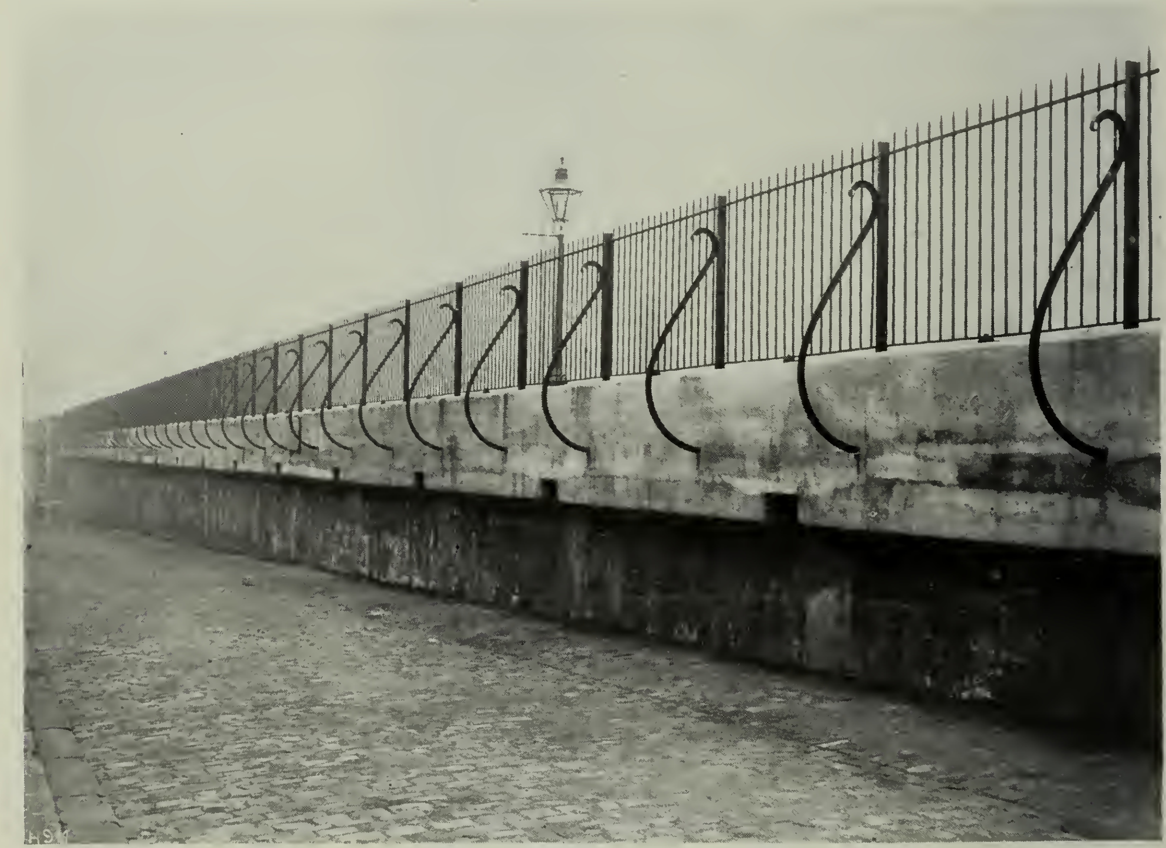
The wall was constructed by direct labour under the supervision of Mr. T. O. Paterson, M.Inst. C.E., engineer to the Birkenhead Corporation Gasworks. and the success of the work demonstrates the simplicity and efficiency of Expanded Steel reinforcement in the hands of ordinary labour under proper supervision.

The Expanded Steel was supplied by the Expanded Metal Co., Ltd., of London and West Hartlepool.

REINFORCED CONCRETE RETAINING WALL, HOPE STREET IMPROVEMENTS, LEEDS.

THE wall shown in our illustration is reinforced throughout its length with 3-in. diamond-mesh Expanded Steel, and a considerable quantity of similar reinforcement was also used in the concrete cover to a culvert under the roadway.

Mr. W. T. Lancashire, A.M.Inst.C.E., City Engineer, was responsible for the work, which was carried out by Mr. Paul Rhodes, contractor, Skinner Lane, Leeds. The Expanded Steel was supplied by the Expanded Metal Co., Ltd., of London and West Hartlepool.



REINFORCED CONCRETE RETAINING WALL, HOPE STREET IMPROVEMENTS, LEEDS.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork where structures of great height are required.—ED.

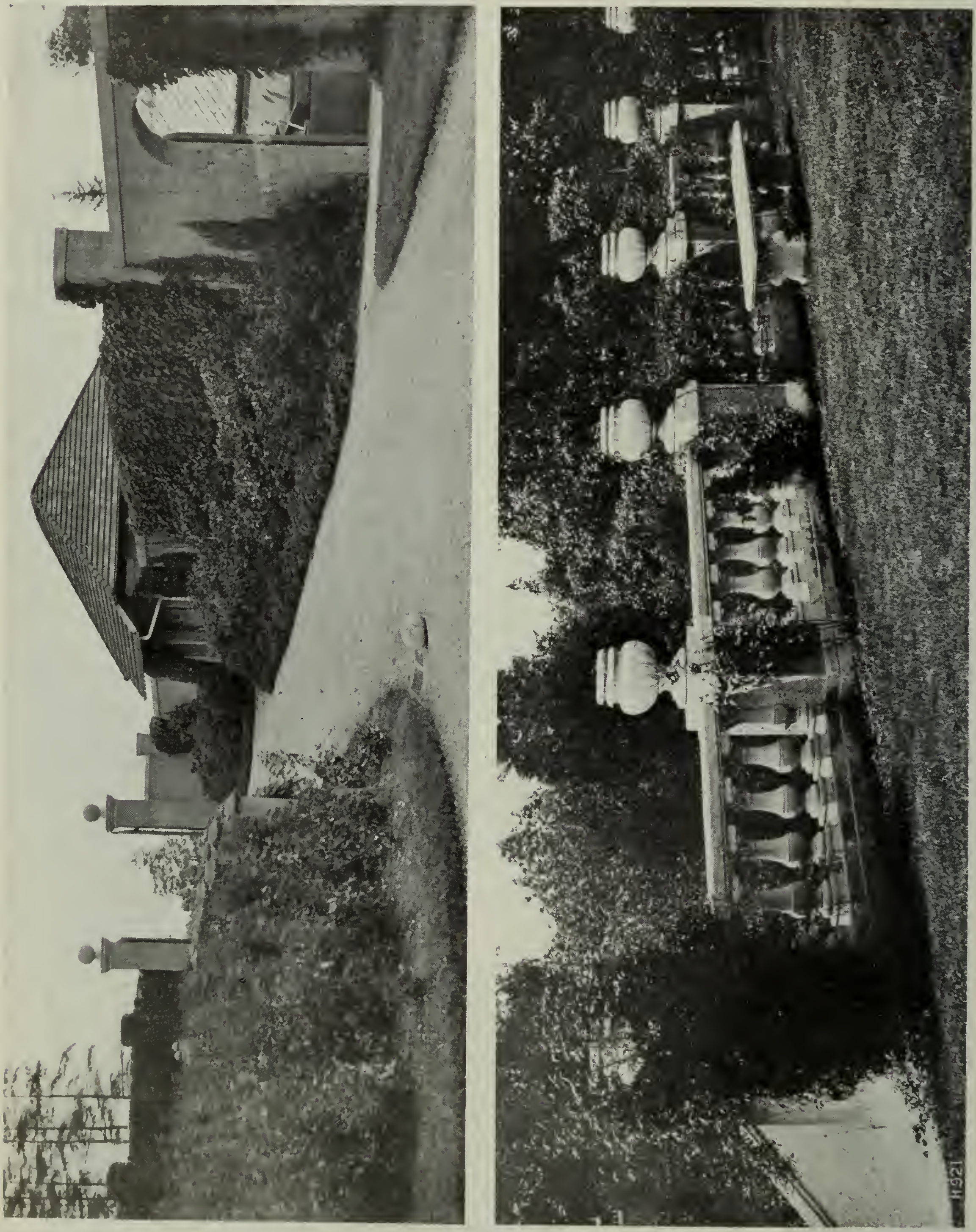
ARTISTIC CONCRETE.

THE examples of the application of concrete for general purposes in the country, given from time to time in this journal, have more generally referred to the farm. We have only occasionally described its application in works of a more extensive and artistic character, such as for gardens, terraces, conservatories, and the like.

We are now presenting a few illustrations from the United States of some recent applications of concrete to the artistic purposes of that class of country property where, as a rule, expense is no object. Even in such cases it would seem that concrete can be applied most usefully and artistically. Owing to its monolithic character, it lends itself best to a monolithic type of architecture, as, for instance, for large areas of wall space, unbroken by joints, and at the same time capable of very varied forms of treatment. Different effects can be obtained by different surface finishes and by different sizes of aggregates.

AN EXAMPLE OF CONCRETE GARDEN WORK.

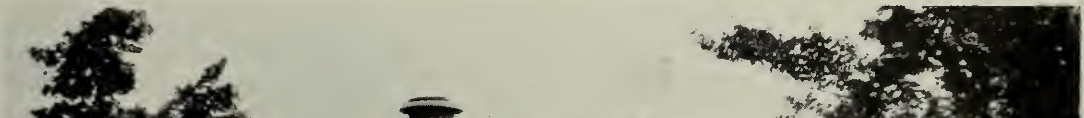
We give two examples of entrances—a park entrance and a garden gate ; also a fine illustration of a terrace, another of ordinary garden wall work broken with gateways and archway openings, and an eminently practical example of large conservatories and frames.



EXAMPLES OF CONCRETE GARDEN WORK.

Anyone seeing these examples will easily realise that any possible adaptation of concrete is applicable to English property, and the owners of our great country estates will also be well advised to think of the advantages of concrete outside estate work proper and farm work, and its use in their parks and gardens.

All the work illustrated in this article was carried out by the Aberthaw Construction Co., of Boston, U.S.A.



Examples of Concrete Garden Work.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"Building in London." By Horace Cubitt, *A.R.I.B.A., P.A.S.I.*, **with special chapters by H. J. Leaning,** *F.S.I.*, **and Sydney A. Smith,** *F.S.I.*

London: Constable & Co., Ltd., 10 Orange Street, Leicester Square, W.C. Price 31/6 net, 800 pp. + xv.

Contents.—County of London, Extent and Administration Acts, By-laws, and Regulations—Streets and Sanitation—Frontage, Height, and Air Space—Construction—Provisions Affecting Both New and Existing Buildings—Miscellaneous Provisions—Cost of Building Work (by H. J. Leaning)—London Property, the Valuation, Development, and Rating (by Sydney A. Smith).

The consideration of the various Acts and by-laws in the County of London is of the greatest importance to architects and engineers engaged in actual practice, and the designer is hampered by so many restrictions and regulations that he is in great danger of finding his design being rejected or amended by the powers that be unless he has had considerable experience in London work. Unfortunately there are so many different interpretations put upon the same clauses by the district surveyors in different districts that the designer is never quite sure of his position when coming in contact with work in a part of London not previously dealt with, and the only safe course for him to adopt is that of thoroughly discussing his scheme with the surveyor before the work is actually commenced. We know full well that certain surveyors are particularly keen on certain clauses which in other districts are dealt with in quite a lenient manner, and thus the architect is for ever meeting with some new difficulty which he was not called upon to meet in previous cases. Now this book has the great recommendation that it brings together all the various Acts which apply to building work, and thus the work of reference is much facilitated and the way of the designer made easier. The inclusion of the actual text of the requirements, in addition to the author's explanation, was absolutely essential, and had this portion been omitted we have no hesitation in saying that the volume would have been quite incomplete, and much of its value lost. The explanation of any statutory requirement is so often based upon what the writer considers to be the spirit of that requirement, whilst the authorities will as often insist upon the actual letter of the requirement, whether or not such requirement is necessary, that many pitfalls waylay the professional man who does not study the requirement for himself.

As now produced, however, the reader may look up the author's explanation and gain an idea of how the requirement may be interpreted and complied with, and at the same time he can refer to the actual text of the requirement, and decide if such explanation is open to any opposition from the person under whose supervision and to whose satisfaction the work is to be carried out. There are some instances in which the letter of the Act can be complied with, while at the same time the real object of the requirement is not attained. Take, for instance, the case in which the ground floor of a building is to be divided into two shops. Now, if these two shops are entered from the same lobby they are deemed to form one building, and there is no restriction as to the dividing partition, but directly they are entered from separate lobbies they are considered as separate buildings, and the divisions must be formed as party divisions. If, however, in the latter case a doorway is formed in the partition the shops become one building, and the restriction ceases. This often leads to the door being formed when it is not really required in order to avoid the restrictions, and the tenants will fasten up the door, and it might, and, in fact, it would, have been better to have omitted it. This we may call compliance with the letter and not the spirit, and such little methods are chiefly acquired by experience.

The author of this volume has, however, given many valuable interpretations and much advice which should prove a great help to the professional men who are in any way connected with building matters.

The inclusion of a few notes as to calculations, we feel, was unnecessary, and can hardly be justified. A little knowledge is a dangerous thing, and we feel that these notes would be quite useless to enable anyone with a very limited knowledge to make calculations which would be of any value, and at the same time the notes would not be required by one who was well versed in the subject. The latter person is the one who should be consulted on a point of structural design, and the former would be well advised to study the subject thoroughly before attempting calculations for actual work, and this can only be done by a course of systematic training.

The method of reference employed in the book, we feel, is very good, and it is a point which is far too often overlooked in works of this kind.

Generally speaking, we consider the volume to be very useful, and have no hesitation in saying that the outlay entailed in its purchase will not be regretted, but rather that it will prove of great assistance in the daily routine, and facilitate the work of the reader.

"Engineering Estimates, Costs and Accounts." By a General Manager.

Third Edition, revised and corrected. London—Crosby, Lockwood & Son, 7 Stationers' Hall Court, Ludgate Hill, E.C. Price 7/6 net. 8vo. xx-256 pp.

Contents. — Introductory — Estimates Technically Considered—Estimates Commercially Considered—General Examples—Indirect Expenses—Millwright Work—Shafting and Couplings—Cast-Iron Belt Pulleys—Rope Pulleys—Toothed Gearing—General Contracts—Miscellaneous Productions—Pumps—Hoisting Machinery —Hydraulic Presses and Pumps—Bleaching Machinery—Brickmaking Machinery—Valves and Taps—Prime Movers—Steam Boilers—Costs Bookkeeping—Table of Wages of Engineering Labour in London and Other Centres.

The subject of estimating for engineering works is of the utmost importance to all in the industry, but it is surprising how few persons have any knowledge of how engineering estimates are prepared. In concrete works there is opportunity for much useful information to be divulged by those who know, but this book does not help quite in that specialised direction. The book deals solely with mechanical engineering. As regards that it is a good book and it throws much light in a general way on the manner of preparing estimates which will help anyone in the engineering industry.

"Reinforced Concrete Beams and Columns." By W. Noble Twelvetrees.

London: Published by Whittaker & Co., 2 White Hart Street, Paternoster Square, E.C. Price 6/- net. 167 pp. + x.

Contents.—Bending Moments and Stresses in Beams—Horizontal Reinforcement in Beams—Web Reinforcement in Beams—Columns and Struts—Column Bases—Complete Floor Calculations — Permissible Working Stresses—Materials and Construction —Labour-saving Diagrams.

This volume is confined to the designing of beams and columns, as may be gathered from the title, and therefore its value is a limited one, and it is hardly likely to be adopted either as a textbook for students or as an essential reference book by the majority of concrete engineers.

Generally speaking, the labour-saving diagrams are the chief feature, and a great deal of the text is devoted to their explanation and examples showing their actual use in practice. These explanations are very clear, and should enable anyone to use them with intelligence, thus saving a great amount of time and labour in actual calculations. There is one thing which, we feel, should have been different, and that is the table of notation. It is a great pity that authors do not attempt to standardise some form of notation which would in time become general, and greatly help to put reinforced concrete formulæ and calculations on some sort of a universal basis. The Concrete Institute has prepared a table of notation which has been well received and adopted by a great number of engineers, and we fail to see why any writer should adopt a different table. The author of this volume himself deplores the lack of agreement that exists over this very same point in his small book entitled "Simplified Methods of Calculating Reinforced Concrete Beams," and also on page 162 of this book, and yet he is not adopting the form which has been approved by the majority of engineers interested in the subject.

The explanations of the construction of the different formulæ should be of value to those who are not very conversant with reinforced concrete calculations, and the author has gone to great trouble to express matters in a simple way, and for this reason the volume is to be recommended.

Examination Work in Building Construction By Henry Adams. *M.Inst.C.E., etc., late Professor of Engineering, City of London College.*

Published by the Author, 60 Queen Victoria Street, E.C. Large quarto. 56 pages. Price 2/6 net.

Professor Adams is, of course, a well-known author on technical subjects, and he has had great experience in teaching both building and engineering students, and as an examiner in such subjects. This book deals with questions set in the examinations of the Society of Architects, and the answers to the questions given will certainly be useful to students of building construction. We notice that Professor Adams shows a good many examples of plain concrete work in foundations and in floors and roofs. He also shows fire-resisting floors of steel joists and concrete, and also of reinforced concrete. The drawings are exceptionally clear, and Professor Adams's contributions of this kind are always interesting and worthy of close study. He has the happy knack of conveying information in the clearest and most direct manner.

EFFICIENCY ENGINEERING.

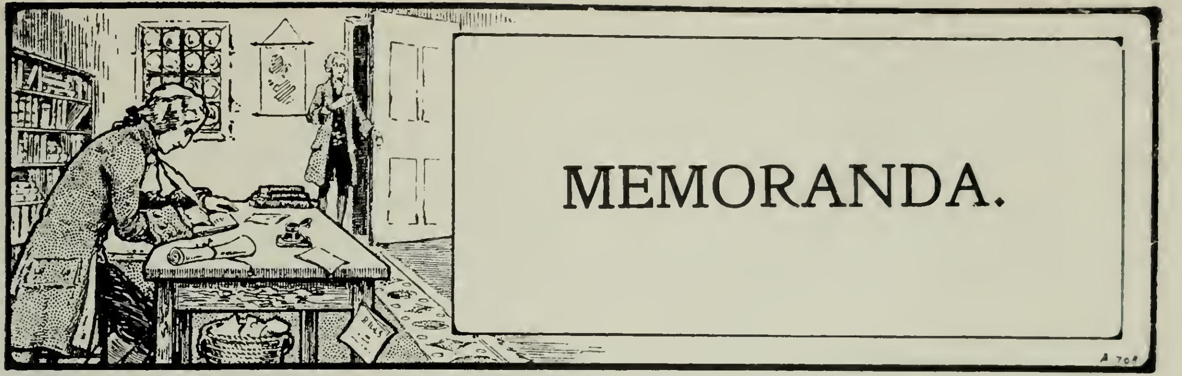
"Motion Study." By Frank B. Gilbreth, *M.Am.Soc.M.E.*

London—Constable & Co., Ltd. Price 4/6 nett. 8vo. xxiv-116 pp.

Contents. — Introduction — Description and General Outline of Motion Study—Variables of the Worker—Variables of the Surroundings—Variables of the Motion—Past, Present and Future of Motion Study.

This work is very important. Mr. Robert Thurston Kent, the editor of "Industrial Engineering," who has written the introduction, goes into panegyrics about it. It certainly awakens very considerable interest, for it touches on a very great problem and affects economics. Mr. Gilbreth has for years carefully studied means by which to increase the efficiency of the worker and he has succeeded in devising means by which the output of work can be very greatly increased, generally doubled and often increased fourfold, by reducing the number and arduousness of the motions gone through by the worker in executing his work. There is, no doubt, tremendous waste of energy in every walk of life, and efficiency engineering is a study that has particularly appealed to Americans. Mr. Kent says: "Some day an intelligent nation will awake to the fact that by scientifically studying the motions in its trades it will obtain the industrial supremacy of the world. We hope that that nation will be the United States." No doubt there is vastly more to be gained in this direction than by husbanding our natural resources. There is waste of power and wastage by natural forces, but it is small compared to wastage of human effort. Therefore, we give every praise to Mr. Gilbreth—an American engineer contractor who has specialised in increasing efficiency—for what he has done in directing our thoughts in this direction.

Mr. Gilbreth does not waste his energies in attempting to show the application of his method to many industries which could only result in want of pertinency. He takes one trade, namely bricklaying, and shows how he has managed to increase the output of the worker by devising a scaffold and way of stacking and handling bricks that do not require so much stooping, bending and turning on the part of the worker, and how he can be trained to do his work with less movement of the tools and hands. The only thing that specially strikes us apart from the general character of Mr. Gilbreth's text, is how badly American brickwork is done, there being little or no bond in the walls. However, that does not interfere with the lessons Mr. Gilbreth has to teach. One example of what can be done by attention to the smallest details is familiar to all—*i.e.*, the reduction in time now needed by firemen in which to turn out of the station fully equipped. That speeding-up can be done everywhere, and our public officials and private officers might alike with infinite profit learn the lesson taught by Mr. Gilbreth.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Technical Institutions.—The Westminster Technical Institute, Vincent Square, Rochester Row, S.W., have sent us their prospectus and time-tables of evening classes for the session beginning September 18th. Among the many technical subjects dealt with at the institute are civil engineering in all its branches, gas engineering, architecture and construction. On Wednesdays, from 8.15 to 9.30 p.m. an advanced class for structural engineering is held, in which a course on reinforced concrete calculations is given.

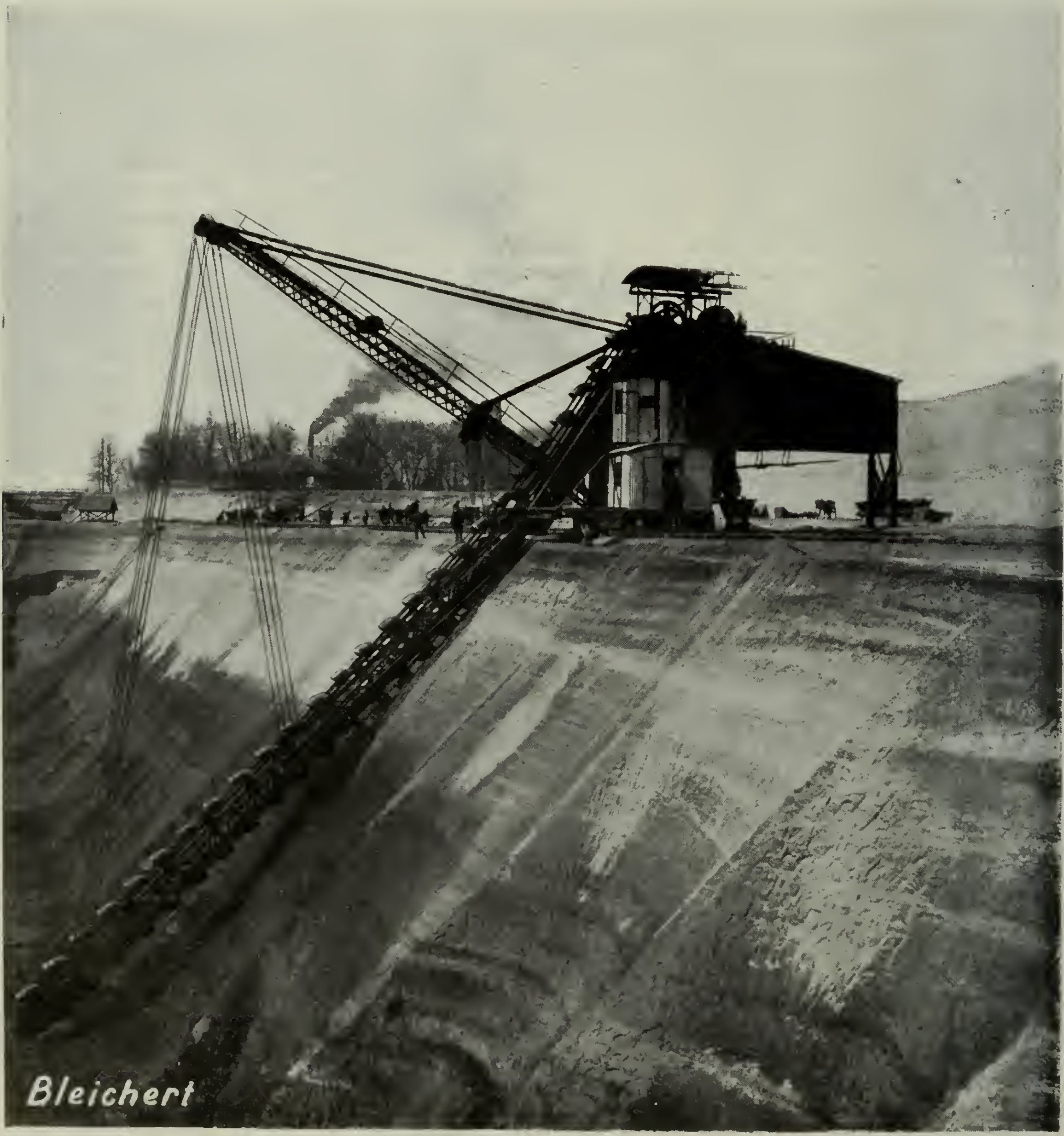
The Regent Street Polytechnic, owing to its having been rebuilt and enlarged, has improved facilities for both day and evening instruction, and newly equipped workshops and laboratories have been provided. To prevent loss of instruction to anyone who cannot attend all the classes, arrangements have been made whereby, for a reasonable number of times, the classwork and homework will be sent to the student on application. Tutorial classes are held every Thursday evening in connection with the regular instruction, which are of special advantage to the students in keeping up with the regular work of the session and in overcoming individual difficulties.

Concrete Lamp Posts.—A number of concrete lamp-posts have been erected at Ann Arbor, Michigan, at a cost, exclusive of labour and material for making the forms, of $7.48 (about 31s.) per pole. The posts are 25 ft. long, 8 in. in diameter at the base, and 5 in. at the top, and are reinforced with four $\frac{3}{8}$-in. steel rods, one at each corner. They weigh 1,185 lb. each. Single or buck arms, bored for $\frac{5}{8}$-in. bolts to support the line wire insulators, are cast into the poles at a distance of 6 in. from the top, for which purpose $1\frac{1}{2}$-in. by $\frac{5}{8}$-in. by 18-in. steel angles are used. The lamp bracket is carried on three $\frac{1}{2}$-in. bolts, which are cast into the concrete 19 ft. from the butt of the pole, and the lamps are hung 12 ft. above the kerb. The concrete was formed of 1 part Portland cement, 2 parts sand, and 4 parts $\frac{1}{2}$-in. crushed limestone. The cement was mixed wet, and was poured and trowelled into the form. The posts were allowed to set two days, and then to lie on the form base for four days longer. Afterwards they were seasoned for 10 days before being erected. In making 100 of these poles 30 tons of crushed stone, 18 bushels of sand, 47 bushels of cement, 4,300 lb. of reinforcing steel, and 600 lb. of cross-arm steel were used. The cost of the material was $326.84.—*The Times.*

Remarkable Excavator for a Hungarian Cement Works.—An excavator has lately been installed in the clay pits of a cement words in Hungary which is worthy of note not only on account of its design but also for its great capacity, as the bucket guide alone has a length of 125 ft. The clay beds are composed of a comparatively light material, in layers of clay more or less sandy and moist, but not sticky, which lies in sixteen clearly defined horizontal layers, the upper ones being richer than the lower. The material was formerly excavated and mixed by manual labour, but some years ago it was determined to substitute mechanical methods. In order to keep the works supplied with material of a uniform nature it was necessary to extract it from the beds—which have a thickness of 66 ft.—in one single clean cut instead of working at different levels. This could naturally only be done by an excavator of unusual design and of very large dimensions, and such an appliance has been supplied by the firm Adolf Bleichert & Co., London and Leipzig, which is shown in the accompanying illustration.

This engine works at a distance of about 1,315 ft. from the engine-house on a track 920 ft. long, and transfers the extracted material from two large drop chutes into trucks running on a chain railway for conveyance to the mill.

The frame of the excavator is made up of rolled sections and strong plates, and is well stiffened by strong cross and diagonal bracings. The bucket chain is driven by an alternating current motor of 75 h.p. The movements of the bucket chain, the travelling of the excavator, and the raising and lowering of the bucket guides are quite independent of each other, and can be worked either simultaneously or successively. The movement is transferred to the bucket chain by two drum sheaves provided with teeth. A belt drive and toothed wheel drive are inserted between these sheaves and the driving motor. The belt is protected from the influence of the weather by plate casing, and, as is usual, the bucket guide is raised and lowered



Excavator for Cement Works.

by means of a drum winch. Dredge buckets are employed for digging out and carrying the material, which are made in one piece from pressed steel plates having a bent shape and discharging to the rear. A knife is screwed on the blade side, which can be easily sharpened or exchanged. The material handled is transferred from the excavator shovels to the loading pockets, from which it is drawn off into chain railway trucks.

The working angle of the excavator guide is 47·5 degrees ; the track is horizontal, with a gauge of about 10 ft. The distance from centre of the travelling track of the excavator to the centre of the chain railway is nearly 14 ft. The projection of the counterweight is about 50 ft., and the counterweight itself, which consists of paving stones, weighs 40 tons. The bucket guide, as already mentioned, has a length of 125 ft., with a dredger depth of about 65 ft. Pendulum feet are fitted on the rear side of the counterweight, which rest when the excavator guide is relieved at any time, and in this manner carry the main part of the counterweight.

This excavator is an engine of quite exceptional character, and, in spite of its unusual size, we are informed that it has proved most reliable and successful in working.

Applying Cement Mortar by Compressed Air.—When concrete or cement mortar is applied as a protective covering to structural steel work, the ordinary method is to surround the steel members with wooden forms and pour the wet mixture into place, some form of wire mesh or metal lath being employed as an anchorage ; but a radically different arrangement is adopted in covering the steel work which forms an important feature of the reconstruction of the Grand Central Terminal yards of the New York Central and Hudson River Railroad in New York City.

The essential parts of the " cement gun " there used consist of superimposed steel tanks forming two compartments, from the bottom of which a dry mixture of sand and cement, entirely under the control of the operator, is ejected by compressed air through a hose line carrying a nozzle at its discharge end. To this nozzle a second and smaller hose delivers a supply of water under pressure. The mixture of sand, cement, and water shoots out of the nozzle orifice with considerable force and impinges upon the surface of the steel work at which it is pointed. The mortar issuing in the form of a spray adheres to the surface of the steel and forms a coating which may be made as thick as desired.

The discharge of the cement and the sand is regulated by varying the speed of a large feed wheel at the bottom of the lower compartment, which has deep notches around its entire circumference. This wheel is revolved by a small compressed air motor, and the small charges of the sand and cement mixture collected in the notches or pockets around the periphery of the wheel are fed successively into the rapidly moving stream of air which issues from the inlet connection. The material is blown through a curved outlet, and passes thence into the hose line supplying the discharge outlet of the gun. The quantity of air required for working the gun depends upon the conditions under which it operates and the nature of the work to be done, and this is also true of the water used to hydrate the cement. The nozzle through which the mixture is discharged is designed to secure the thorough hydration of the cement, and that portion of it which is exposed to the abrasive action of the sand is lined with a composition that can be readily replaced as wear takes place. The water comes in contact with the mixture of cement and sand just as it passes through the nozzle, which is furnished with an annular chamber from which the water is sprayed under pressure from a series of carefully proportioned orifices, and the hydration is begun there and continues until the surface to be covered is reached.

The mixture issues from the gun nozzle at a velocity of about 350 ft. a second, and when it strikes the steel surface the large and coarse grains of sand rebound until the thin film of fine cement mortar which immediately adheres to the steel offers a plastic base in which the coarse particles become embedded ; the mixture then builds up to any desired thickness upon this film. It is apparent, therefore, that when the swift moving stream of material hits the steel surface, and between that time and the instant when the mortar cover begins to build up, there is a tendency for the sand grains to clean off any rust after the manner of an ordinary sand blast. The deposition of the thin film of cement against the steel is advantageous, as it secures an excellent

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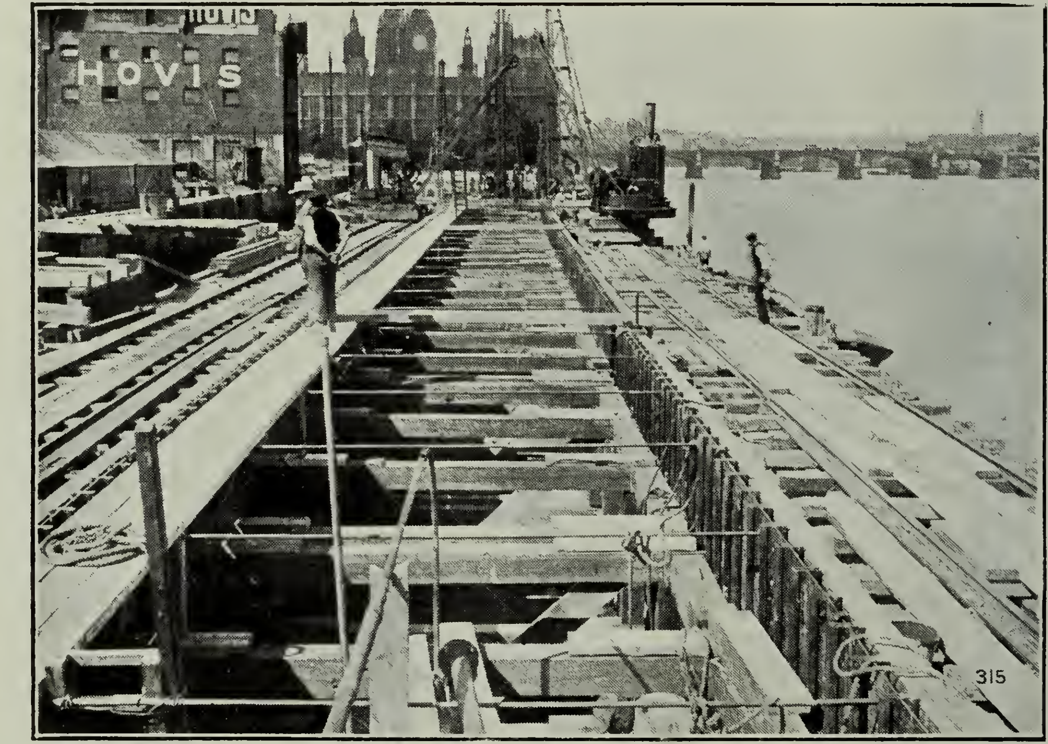

Illustration shows our 15 in. × 43 lb. Piling in use on the new Embankment Wall at Millbank, Westminster. The dam shown is 210 feet long by 13 feet wide. The piles at front are 44 feet long, and at back 41 feet. These were driven through river ballast and sand into London clay. Same will be withdrawn and used three times.

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bond and makes an efficient protective covering over the metal. As the cement is literally shot upon the steel a coating of great density is secured, while the force of the impact drives out all superfluous water, and the concrete takes its initial set in a very short time, all possibility of voids or air pockets being avoided.—*The Times.*

Economical Proportioning of Concrete.—The following remarks by Mr. Sandford E. Thompson, Consulting Engineer, of U.S.A., regarding proportioning of concrete, are useful :—" Economical proportioning of concrete does not always consist in using the leanest possible mixture. If the quantity to be laid is small, it is sometimes cheaper to use materials at hand, selecting the proportions arbitrarily and adding an excess of cement to ensure the required strength and watertightness, rather than to make the tests required for the more scientifically proportioned mixture. On the other hand, upon large or important work it pays from the standpoint of dollars and cents to make thorough studies of the aggregates, carefully grading the materials so as to use the smallest possible quantity of cement, which is always the most expensive ingredient.

" The fact has been seriously overlooked in the past, and thousands of dollars sometimes have been wasted on single jobs by neglecting laboratory tests and studies or by errors in theory. By adjusting the proportions of the aggregates instead of selecting them arbitrarily a concrete of equal density, strength, and watertightness may be made almost always with the use of less cement. On a certain job, for example, where watertight concrete was required, a net saving was effected of 74 cents per cubic yard by carefully grading the materials, the resulting concrete being as watertight as the richer mixture, having proportions selected by judgment."

TRADE NOTICES.

Dentile Hollow Floor Construction.—The Indented Bar and Concrete Engineering Co., of Queen Anne's Chambers, Westminster, have taken over the patent rights of a new form of fire-resisting floor. This is known as the Dentile hollow floor construction, and is composed of hollow tiles reinforced with Indented bars.

Three different types of floors may be constructed on this system to suit different conditions. In that known as the " Mitre " method, each unit consists of four wedge-shaped portions which fit accurately together and form a closed hollow block. By this means reinforcement can be used in both directions, thus making it possible to have a very large span without beams. The whole under-surface of the floor is completely covered by the tiles, which are roughened to receive plaster, no concrete being exposed.

Another method, known as the " Bridge " tile, is intended for use on small spans in which the reinforcement only goes one way. It affords a complete tiled surface on the underside of the floor for the reception of plaster.

The third type, known as the " L " tile, is adapted for use with a two-way reinforcement.

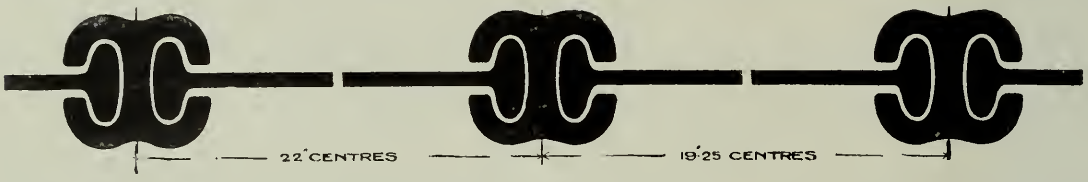
Among the advantages claimed for this method of floor construction are lightness, rigidity, the fewer beams required, and the additional amount of head-room obtainable.

" Ceresit " Waterproofing.—A steady increase in the use of " Ceresit " for waterproofing purposes has been noted during the present year, a large number of repeat orders having been received from Government Departments, railway companies, and other public bodies. At the moment " Ceresit " is being employed by the London and North-Western Railway Co. for the waterproofing of two passenger subways at Stonebridge and Bushey, and Messrs. Vickers, Ltd., are about to use it for a large tank, which they are to construct at St. Albans. The tank, which will be of concrete will be rendered with " Ceresit " mortar varying in thickness from 1½ in. to 2 in., the total area of the rendering being 2,022 sq. yds., for which 500 gals. of " Ceresit " will be required.

A New Method of Steel Piling.—The Side-Groove Steel Piling Supply Co., of 16 Water Lane, Great Tower Street, London, E.C., have sent us particulars of their method of piling which has just been put on the market. The superiority of steel over wood piling has been firmly established, and there are also occasions when it is more practicable than reinforced concrete piles, particularly when very hard soil is met with. The utility of steel piling for cofferdams is also well known. There is also a large field for its use in harbour and dock walls, sea defences, canal, reservoir, and irrigation works.

In such cases it can either be employed alone or in conjunction with reinforced concrete construction. In building docks, wharfs, and sea-walls the steel can be faced with concrete without the cost of special moulds. The concrete prevents any possible corrosion of the metal, and also increases the strength of the structure. The two combined, while saving much in the cost of masonry, give the maximum strength with the minimum structural load on the subsoil.

The patent side-groove steel piling and oval bulb sheetings were designed by Mr. R. H. Annison, after many years' experience with river, dock, and canal works, upon curves entirely free from angles liable to fracture. The pile bar, of which a section is shown in our illustration, is calculated to withstand driving into the hardest soil, whilst the side grooves ensure a straight drive, the thick claws coming well over the sheeting which passes between them. The clearance given allows of free driving without play when naturally caulked by soil, but at the same time it is sufficient to enable the gradual contour of a river embankment to be followed without straining the claws of the pile. The oval bulb sheetings reduce the stress of driving to a minimum. The combination of side-groove steel pile bars and oval bulb sheetings is held by the designer to provide the greatest strength against direct overturning, as well as lateral, stresses.



An advantage claimed by the makers of the side-groove steel piling is that their pile bars, being in most instances sufficient to retain the work in position and withstand all stresses, the sheetings can be stopped at any required point or upon reaching self-sustaining soil. Extensive economy is thus effected by the saving in weight, both in material and transport.

The sheetings are manufactured in two widths, 20 in. and 18 in., giving 22-in. centres and $19\frac{1}{4}$-in. centres respectively. The weights assembled vary from 33·9 to $45\frac{1}{2}$ lb. per ft. super, according to the depth the sheeting is carried down. All the sections are of British standard material.

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Three feet long to Nine feet long.

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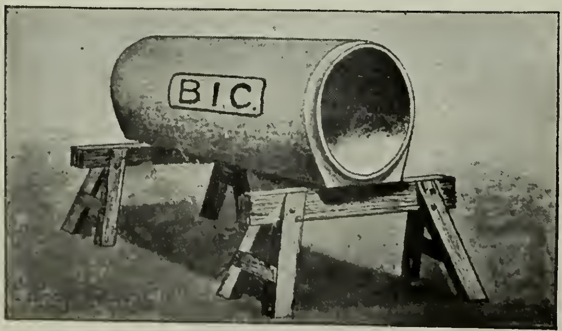
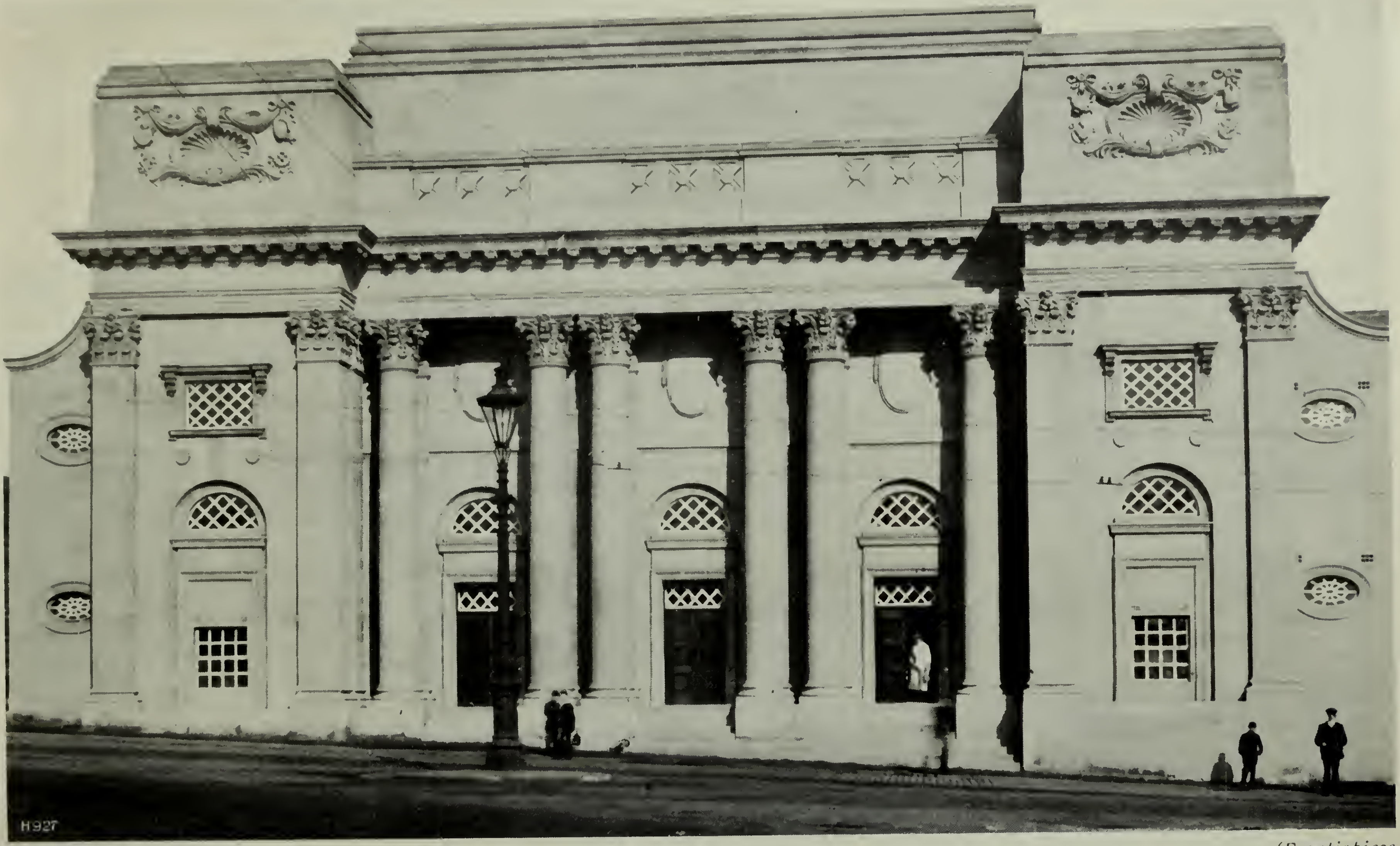


Porous Pipes
Concrete Beams
Hollow Floors

SPECIALITY:—INVENTORS' DESIGNS CARRIED OUT TO ORDER.



View of completed Structure. (*See article on page* 869.)
Burslem Public Buildings.

(Frontispiece opp. Contents)

CONCRETE AND CONSTRUCTIONAL ENGINEERING

Volume VI. No. 11. London, November, 1911.

EDITORIAL NOTES.

FIRE-RESISTING CONSTRUCTION FOR THEATRES.

We have received from the British Fire Prevention Committee a copy of its report, No. 157, dealing with the Edinburgh Theatre fire of May last. Whilst the problem of planning a theatre only indirectly concerns us, we think that this is an opportunity to point to the importance of architects who are responsible for theatre construction studying to a greater extent than heretofore the great advantages of using reinforced concrete, where not only fire resistance is a matter of importance, but constructional difficulties are met with that can be most economically overcome by the application of reinforced concrete.

The report before us, which is profusely illustrated, shows a building largely constructed of brick, with some slight use of steel girders and an undue profusion of timber work.

There is not the least reason why a building of this kind should not be constructed practically entirely of reinforced concrete, or that at least a large part of the tiers, the staircases, the majority of the floors and the entire roofing should not be of that material.

In the photographs shown in the report the wall for the proscenium opening is covered with an unprotected steel girder; the whole of the roof over the stage shows charred timbers. Poor construction of this character was not even necessary when the building was erected more than fifteen years ago, but it is entirely out of place in new buildings erected to-day.

Unfortunately, however, poor construction of this description is even being applied in theatres during the present year, and it might be well if one of the results of the sad fire in Edinburgh were some legislative action for the whole of the United Kingdom and Ireland prohibiting second-class dangerous construction of this kind, and making the use of fire-resisting construction throughout a theatre building compulsory. Given such compulsion as to fire-resisting construction, there is no doubt that most theatres would then be erected in concrete and reinforced concrete, and that the risk to life both for the audience and for the stage personnel would be materially reduced.

SOME AMERICAN VIEWS ON FIRE RESISTANCE.

The Concrete Institute opened its new session with a particularly interesting evening meeting at Denison House, Westminster, under the chairmanship of Sir Henry Tanner, C.B., when Mr. Richard L. Humphrey, President of the

National Association of Cement Users of America, lectured on "Fireproofing," and illustrated his observations with a most remarkable set of lantern-slides taken from notable American fires, in which the relative fire-resistance of terra-cotta, concrete, and other materials was shown.

The lecture was well deserving of a large and extensive attendance of all the interests concerned, and the subject should, even when addressed to one particular class of hearers—namely, the members of the Concrete Institute—bear fruit by its weighty and indisputable arguments in favour of the use of concrete for fire-resisting purposes.

It was a pleasant feature of this particular paper that Mr. Humphrey dwelt on the beneficial effect in the United States of the English investigations on the question of fire-prevention conducted by the British Fire Prevention Committee, which is another proof of the benefits to be derived from this particular class of research work.

INTERNATIONAL TESTING ASSOCIATION.

SOME months back we referred to the impending course of the International Testing Association to be held in the United States in 1912, and suggested that some mutual action should be taken by the British Members Association in order to assure Great Britain's being properly represented at that course by workers of influence. We even ventured to indicate that a meeting of the British members would not be out of place, but apparently nothing has been done as yet in this direction.

The time is rapidly approaching for putting in British contributions either in the form of communications or papers, and also for handing in any proposed resolutions.

Great Britain plays an important rôle in the production of Portland cement, in the investigation of that material, and latterly, also, in its application in concrete both ordinary and reinforced. Further, the number of British members in the International Testing Association connected directly or indirectly with Portland cement and in concrete are comparatively numerous, and we would thus remind them of the advantage of mutual action.

There does not seem to be the least reason why Portland cement specifications and tests should continue to be drafted mainly under German influence, nor is there the least reason why the technical nomenclature or signs of calculus should be mainly the French ones for the Continental countries, and the American ones for the English-speaking countries ; surely the efforts of the Concrete Institute in this direction should be strongly supported at the American meeting.

There are numerous other points of interest to this country, but it would lead too far to enter into them. Expressed plainly, however, apathy regarding the work of the International Testing Association often means that Great Britain has to take, quite unnecessarily, a back seat, that our captains of industry meet with inconvenience, and that our export houses are becoming more and more handicapped in their efforts to control the trade of the world. The sooner those concerned wake up to the importance of meetings of the Association, and the extraordinary influence that has been brought to bear upon them during the last decade by Germany and America in particular, the better for the development of certain of our industries.

THE DESTRUCTION OF THE AUSTIN DAM.

The destruction of the Austin Dam on September 30th last has been the subject of a considerable amount of erroneous information in the popular and technical Press at home. The dam has been in many cases described as of reinforced concrete. It was nothing of the sort. It was a concrete structure which had at certain points been slightly reinforced with metal, but to describe it as constructed of reinforced concrete is quite inaccurate. Secondly, certain other papers commented upon the accident as being due to the fact that it was of concrete. This, again, is erroneous, for the failure was not due to the body of the dam at all, but to unsatisfactory foundations. Besides, the dam had already failed to a certain extent long before the disaster of September 30th, and, owing to delay for some inexplicable reasons, the damage had not been made good.

It is an unfortunate sign of the times that in the haste and hurry prevalent in the newspaper Press such a vast amount of wrong information is constantly being printed, particularly on technical matters. It would really be a great deal better if, after reporting the fact of a disaster, the giving of reasons or causes were postponed until proper information came to hand, but by that time, no doubt, the period of the nine days' wonder would have elapsed, and the whole subject, no matter how serious, would slumber in forgetfulness.

American technical papers have now come to hand, but they refrain from giving their own ideas on the subject except to reiterate the fact that it was due to faulty foundations, the dam having slid forward on its base until it toppled over. Full investigations of the disaster are promised by various American authorities, and we shall look forward with interest to their findings.

WARRINGTON BRIDGE.

After many years' discussions in the Town Council and innumerable delays the reconstruction of Warrington Bridge has now assumed a practical form; after a memorable fight in the committee rooms of both Houses of Parliament, extending over two sessions, the Royal Assent was obtained, the contract was let, and the first two piles were driven on October 5th by the Mayor and the Chairman of the Bridges Committee.

The existing bridge is a fine stone structure and in good condition; but as the distance between the inside of the parapets is only 28 ft., this width is far too narrow for the present traffic, especially as two tram lines cross the bridge. It was first proposed to widen the present bridge, but this plan being unsatisfactory in many ways, it was decided to rebuild the bridge in reinforced concrete.

The new bridge has been designed by Mr. John J. Webster, M.Inst.C.E., of Westminster, who has adopted the Considère system of reinforcement in the construction.

The bridge will consist of a one-arch span 134 ft. clear between the abutments, the width between the parapets being 80 ft., consisting of a 60-ft. roadway and two 10-ft. footways.

Eight main ribs will carry the roadway, and two outer ribs the footways, vertical posts on the ribs supporting the main longitudinal and transverse beams of the roadway deck or flooring upon which are laid Jarrah wood blocks for the roadway and granolithic slabs for the footways. The ribs are parabolic in form, their underside at the centre of the span being 17·42 ft. above low-water level, which is 9 ft. above ordnance datum, while the centre line of the rib at the springing is 5 ft. 6 in. above low-water level. The depth of the main ribs normal to the centre line at a point 5 ft. from the abutment is 3 ft., the width being 3 ft. 9 in., and the section at the centre is 2 ft. 9 in. deep by 3 ft. 9 in. wide, the ribs having cross bracing at intervals. The foot of the ribs is carried through into the abutments, opening out into well-bracketed counterforts which are attached to the base plate. The base plate is vertical for a depth of 5 ft. at the land side, and at an angle of 30 deg. to the horizon for a length of 16 ft., and is carried forward to form a horizontal platform 12 ft. wide for the dead-weight of the earthwork, the face next the river being vertical to form a river wall 12 ft. high. The whole is monolithic, and reinforced throughout with steel rods of varying diameter. The base plate rests upon nine octagonal reinforced concrete piles driven normal to the face of the base plate, the centre of the piles being in line with the resultant of the dead load stresses. The concrete piles are of the Considère type, the spiral reinforcement protecting the pile to a large extent from the action of the falling monkey when driving. The vertical steel reinforcing rods of the piles are carried into the abutment.

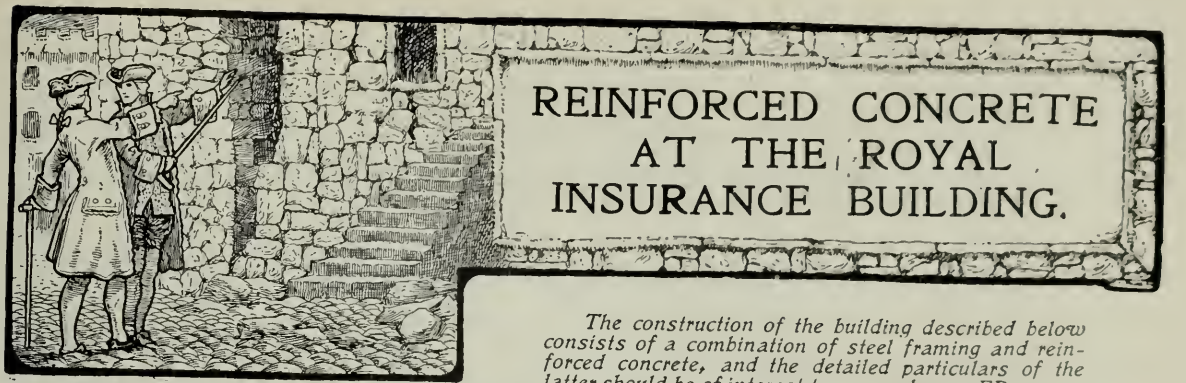
The top and bottom reinforcement of the main ribs consists of steel bars running longitudinally the whole length of the ribs, and of varying diameter and number according to the stresses. The spirals in top and bottom of the rib are 9 in. in diameter by $\frac{5}{16}$ in. and $\frac{1}{4}$ in. diameter, pitched 2 in.

The floor under the footpaths is of special construction, prepared to receive three water pipes 1 ft. 6 in. in diameter, three gas pipes 1 ft. 6 in. in diameter, compressed air pipes, telegraph and telephone cable ducts, etc. A deep-moulded cornice is fixed below the parapet handrail, consisting of ornamental moulded balusters, plinth, pedestals, top rail, etc. The handrailing is returned at the ends with a circular face leading to two tall pedestals and intermediate handrailing on the top of the river walls. The pedestals are 10 ft. high by 3 ft. 6 in. by 3 ft. 6 in. for carrying the electric lamps. The end pedestal is 8 ft. 6 in. high, 3 ft. by 3 ft., and carries an urn or other ornamental terminal.

New river walls of reinforced concrete, strengthened by counterforts and anchor bars, are to be built on both sides of the river, surmounted by ornamental parapet-railing similar to that on the bridge.

The cost of the bridge will be about £20,000, and it should be completed within two years.

The contractors for the work are Messrs. Alfred Thorne & Sons, Westminster, the resident engineer being Mr. J. Mansfield Cobb, assisted by Mr. Grenville Hodgson, who will inspect and test all the material on the site.



REINFORCED CONCRETE AT THE ROYAL INSURANCE BUILDING.

The construction of the building described below consists of a combination of steel framing and reinforced concrete, and the detailed particulars of the latter should be of interest to our readers.—ED.

THE new premises of the Royal Insurance Co. are now being erected in Lombard Street from the designs of Messrs. Gordon & Gunter, FF.R.I.B.A., and, although the general framing is being executed in steel only, many features of interest, from a constructional point of view, are being carried out on the Considère system of reinforced concrete. The adoption of this material for the parts of the work herein described is but another example illustrating the great value of reinforced concrete in modern construction,

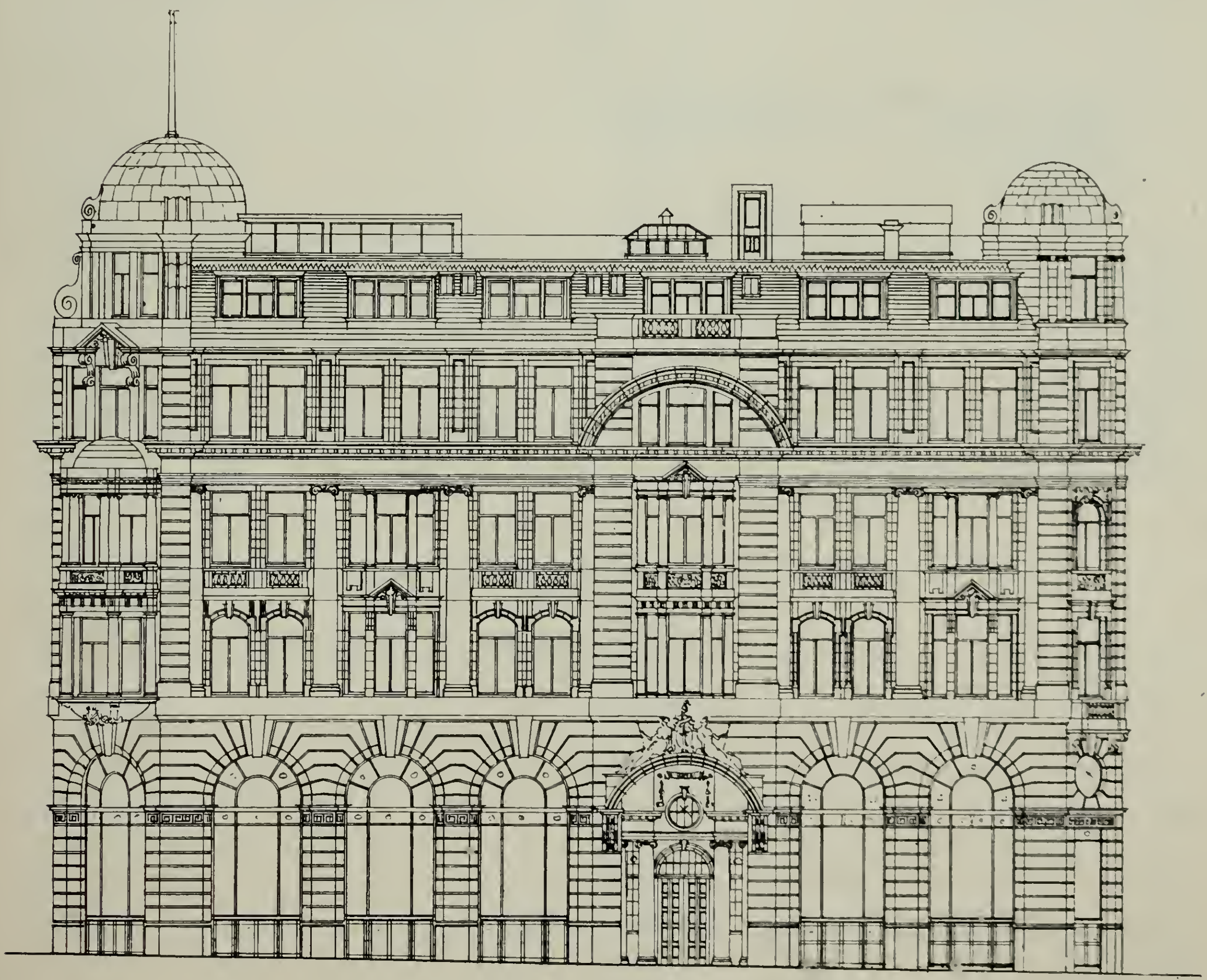


Fig. 1. Elevation.
REINFORCED CONCRETE AT THE ROYAL INSURANCE BUILDING.

especially in London work, where the extreme importance of obtaining every available foot of floor space, together with economy and speed of erection, can hardly be overrated. The enormous progress made in recent years is well illustrated when we realise that the adoption of reinforced concrete in important buildings has now become the rule rather than the exception, and its use is daily becoming more frequent.

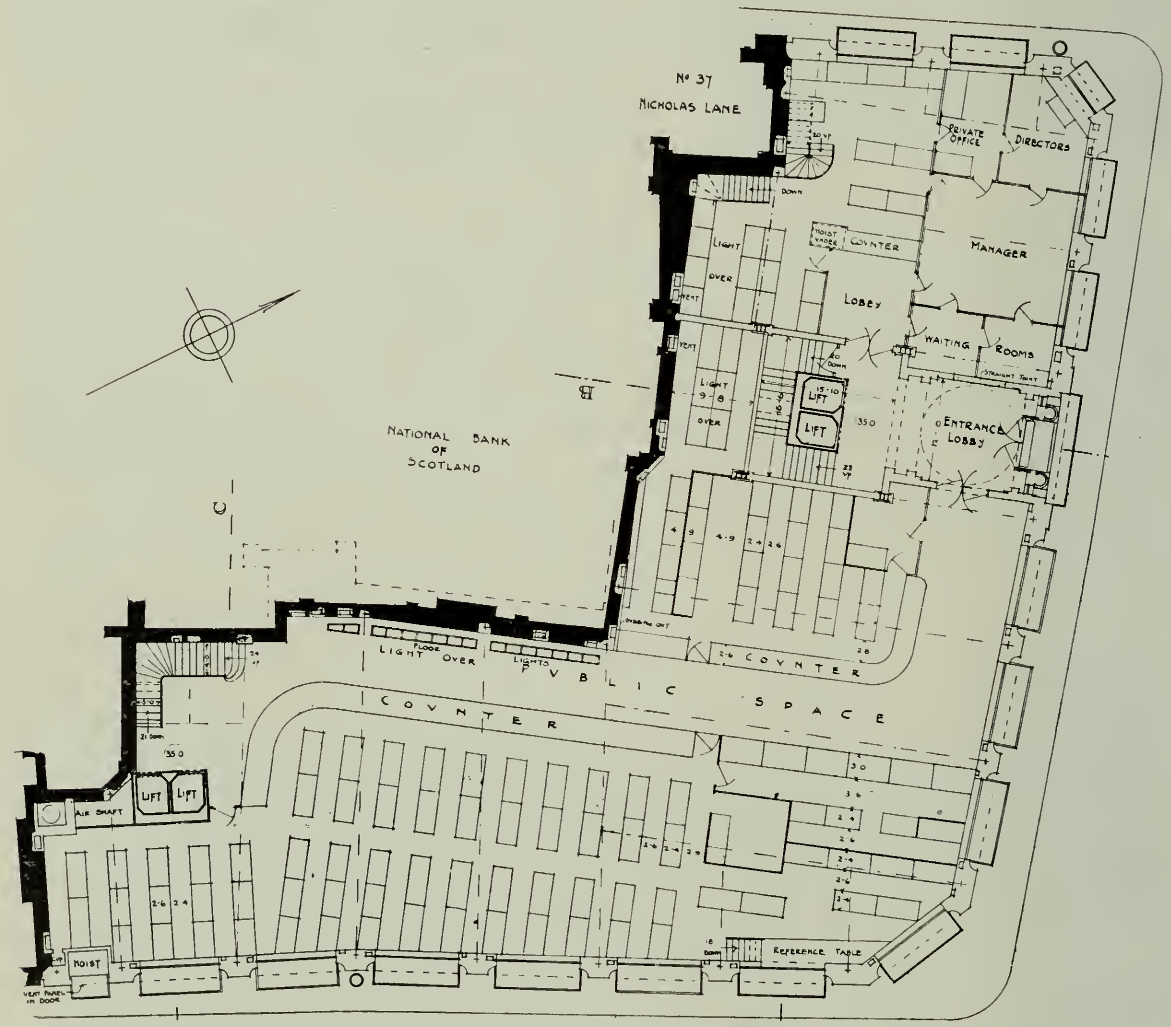
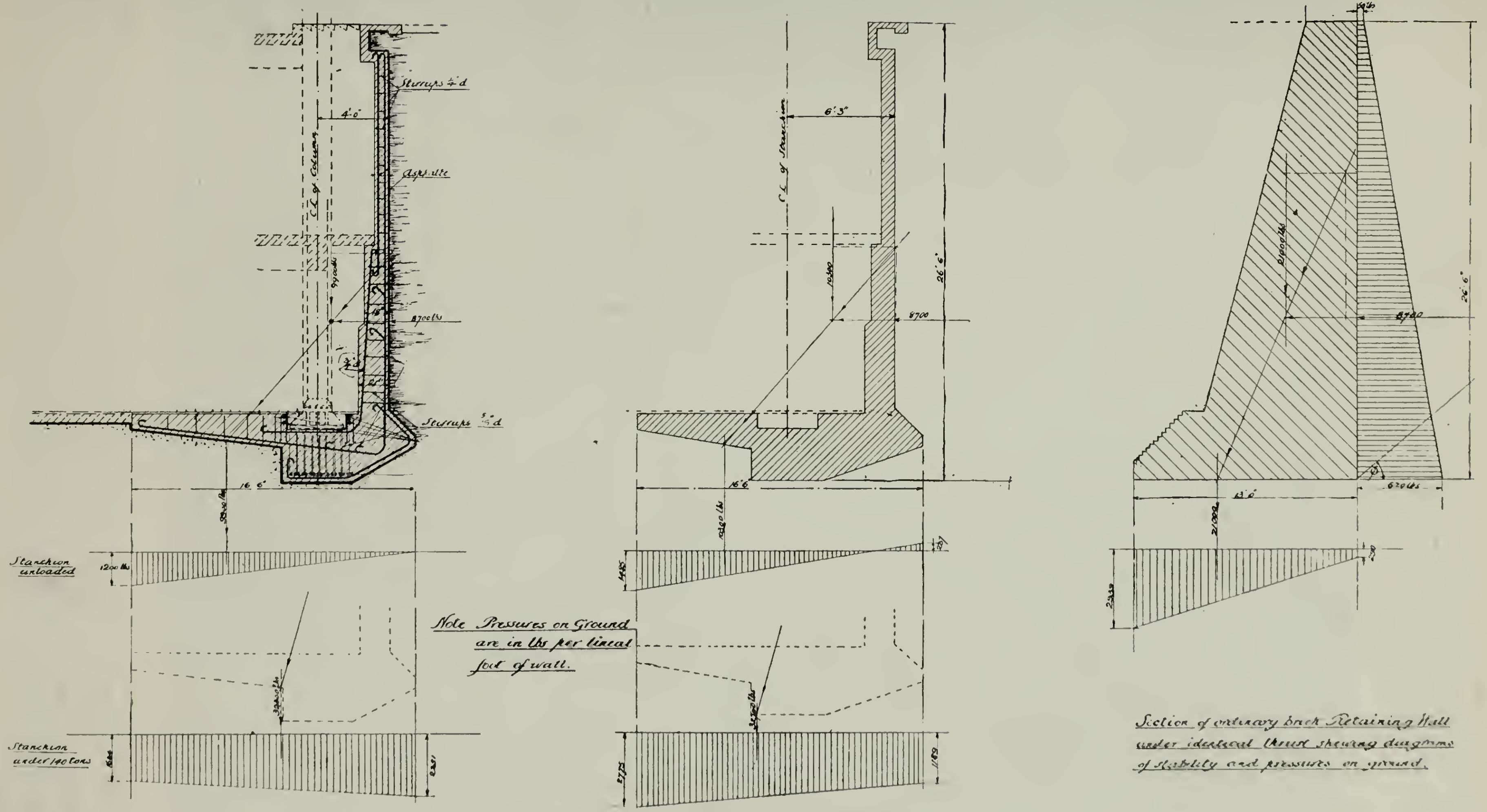


Fig. 2. Plan of Ground Floor.

Reinforced Concrete at the Royal Insurance Building.

The building described in this article has a total frontage to the adjacent thoroughfares of about 240 ft., the site being L-shaped and about 100 ft. long on the two main frontages, and about 40 ft. wide. There are two floors below the pavement level, the lowest floor line being about 21 ft. down, and this necessitated a retaining wall of considerable strength. Reinforced concrete was adopted, owing to the desirability of obtaining the maximum floor area in the basement and sub-basement, this wall for which is an excellent example of scientific design, as will be seen from the drawings, illustrated in *Fig.* 3. The total height from the under-



Note Pressures on Ground are in lbs per lineal foot of wall.

Section of ordinary brick Retaining Wall under identical thrust showing diagrams of stability and pressures on ground.

Fig. 3. Sections of Reinforced Concrete Retaining Wall.
Reinforced Concrete at the Royal Insurance Building.

side of the toe at the deepest point is 26 ft. 6 in., and the greatest thickness at the bottom is only 21 in., this being carried up for a height of 5 ft., while the next 5 ft. is reduced by an offset on the inside to a thickness of 18 in. At this level the underside of the intermediate floor is reached, and a further reduction is made to 10 in., and this thickness is carried to the top. The back of the wall is vertical, and the heel has a projection of 18 in. beyond this line, being splayed at top and bottom to the extreme projection, and having a thickness at this point

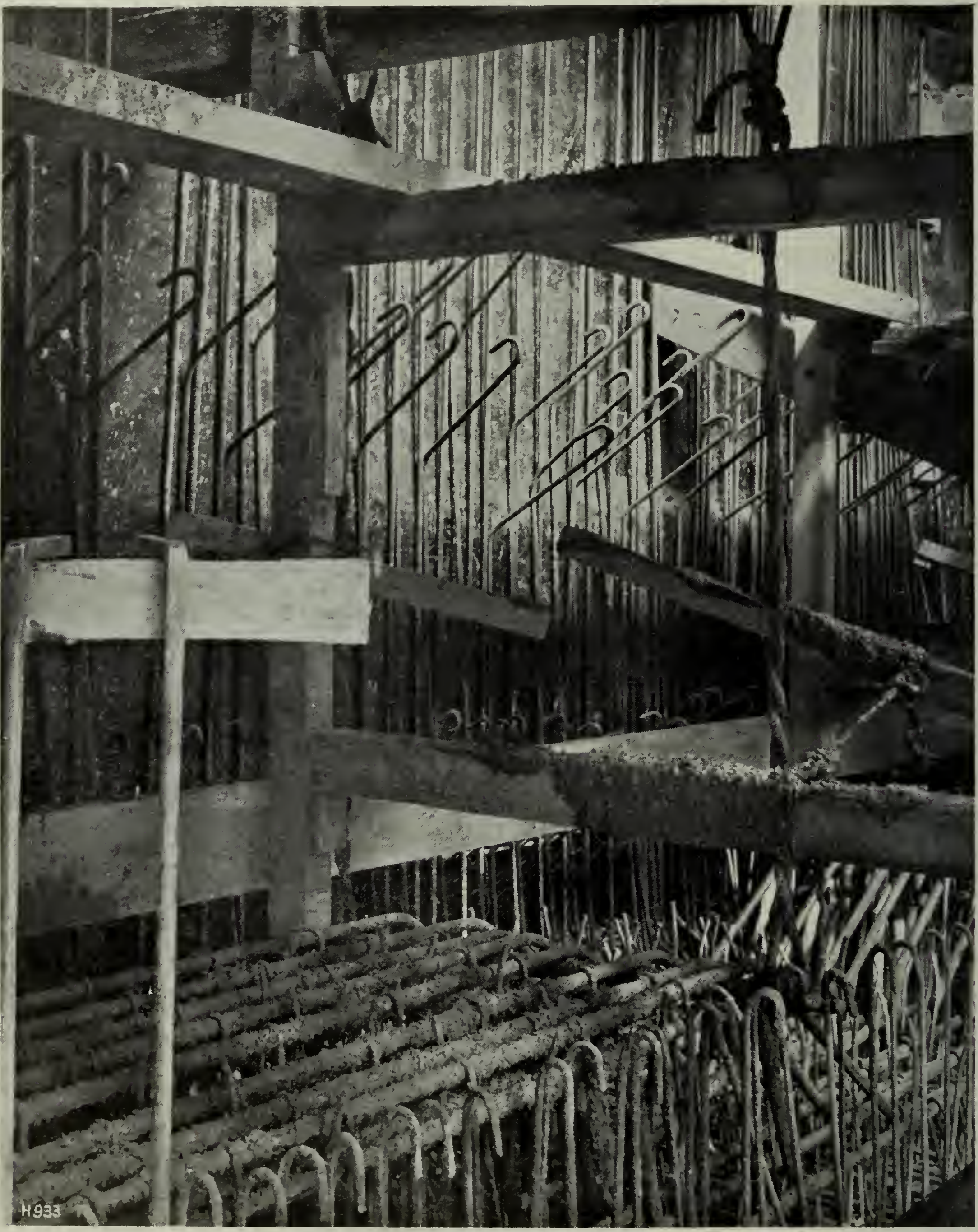


Fig. 4. View showing Reinforcement of Retaining Wall.
REINFORCED CONCRETE AT THE ROYAL INSURANCE BUILDING.

of 9 in. The total length of the toe and heel combined is 16 ft. 6 in., the former having a minimum thickness of 12 in., and being splayed on the underside to give a thickness of 24 in. at the point where a beam is formed to distribute the concentrated vertical loads from the stanchions carrying the main walls of the superstructure. These stanchions are spaced at about 14-ft. centres, and the bases are let down into the toe about 10 in., with reinforced concrete, 3 ft. thick, below this part to form the beam above mentioned, reinforcement

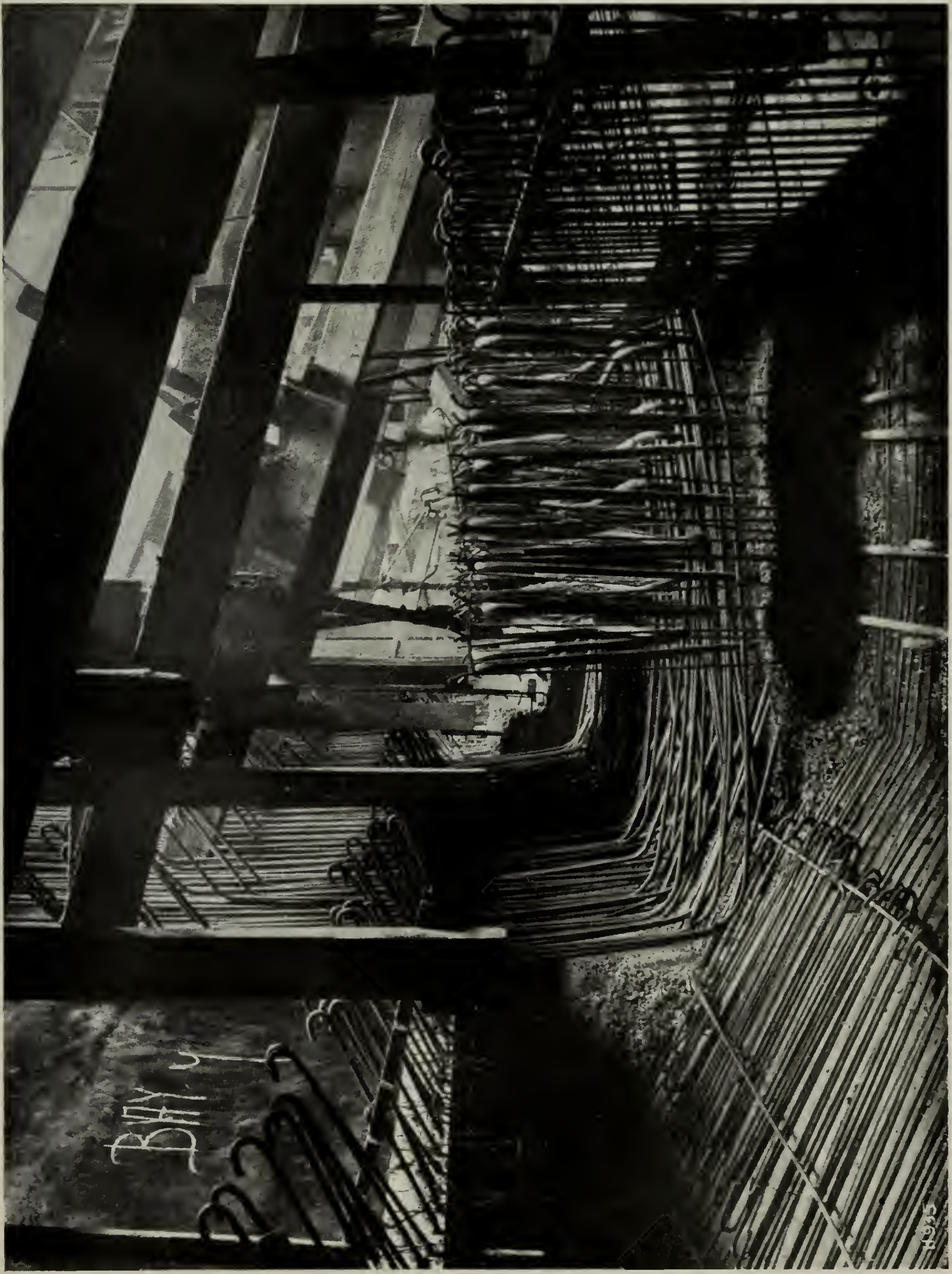
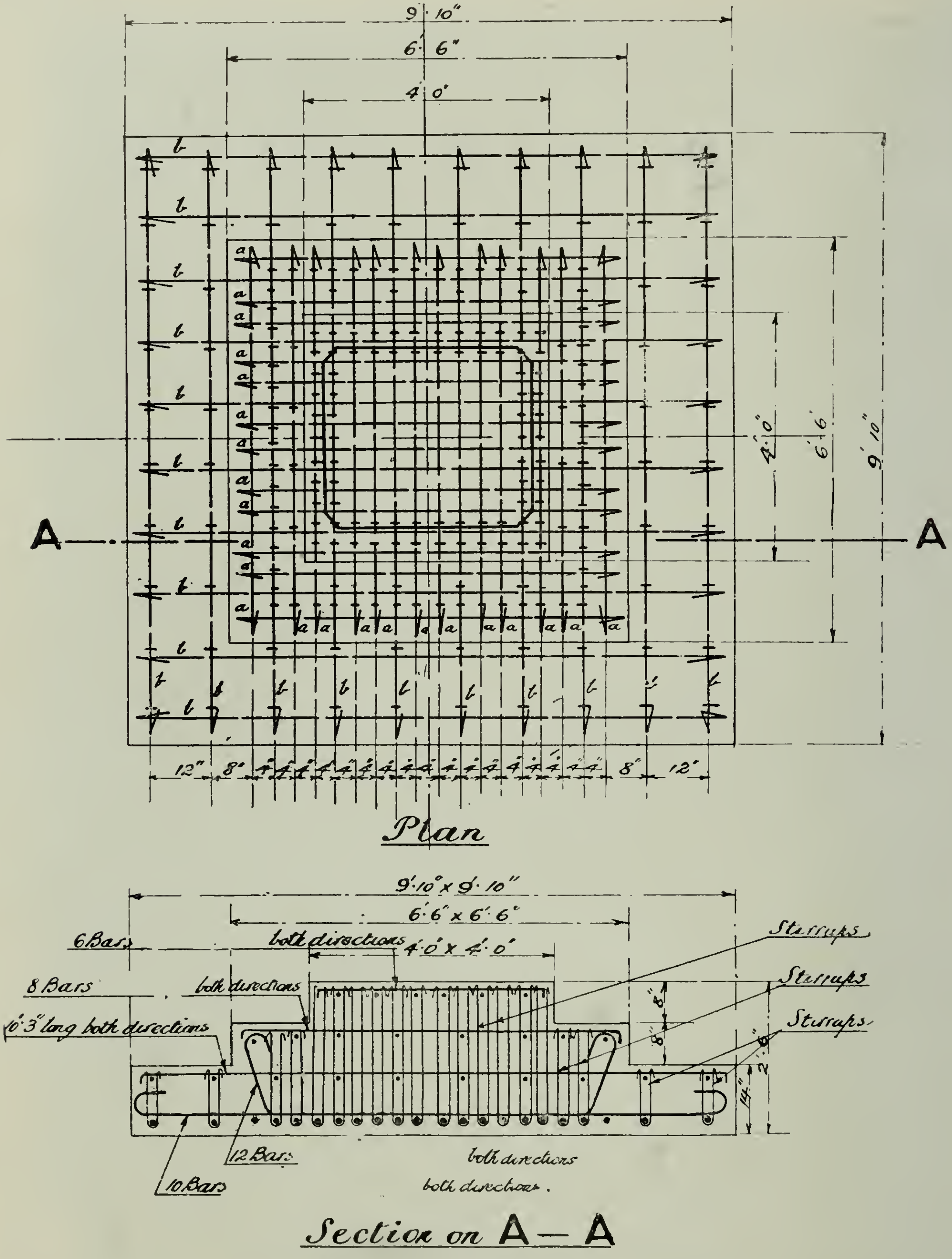


Fig. 5. Retaining Wall in Course of Construction.

Reinforced Concrete at the Royal Insurance Building.

consisting of 16 bars in the section, as indicated on the drawings. The wall itself is reinforced with vertical bars and horizontal stirrups to take the shearing stress, as shown on the section, while the number of bars and their shape and disposition are well illustrated in the photographs in *Figs.* 4 and 5, which were taken previous to concreting. No space was available for counterforts, and calculations were necessary to ascertain the stability of the wall thrusts



Plan

Section on A — A

Fig. 6. Plan and Section of Foundation Slab.
Reinforced Concrete at the Royal Insurance Building.

under the different conditions, as before and after the stanchion loads came upon the distributing beam, these loads themselves also varying. The diagrams illustrated in *Fig.* 3 are interesting as showing the different unit pressures on the soil under the various conditions, and the section of an ordinary brick retaining wall is given under identical thrust, showing diagram of stability and pressure on the soil. It will be seen that the minimum thickness that could be employed in the latter case is 13 ft., and when this is compared with the maximum thickness

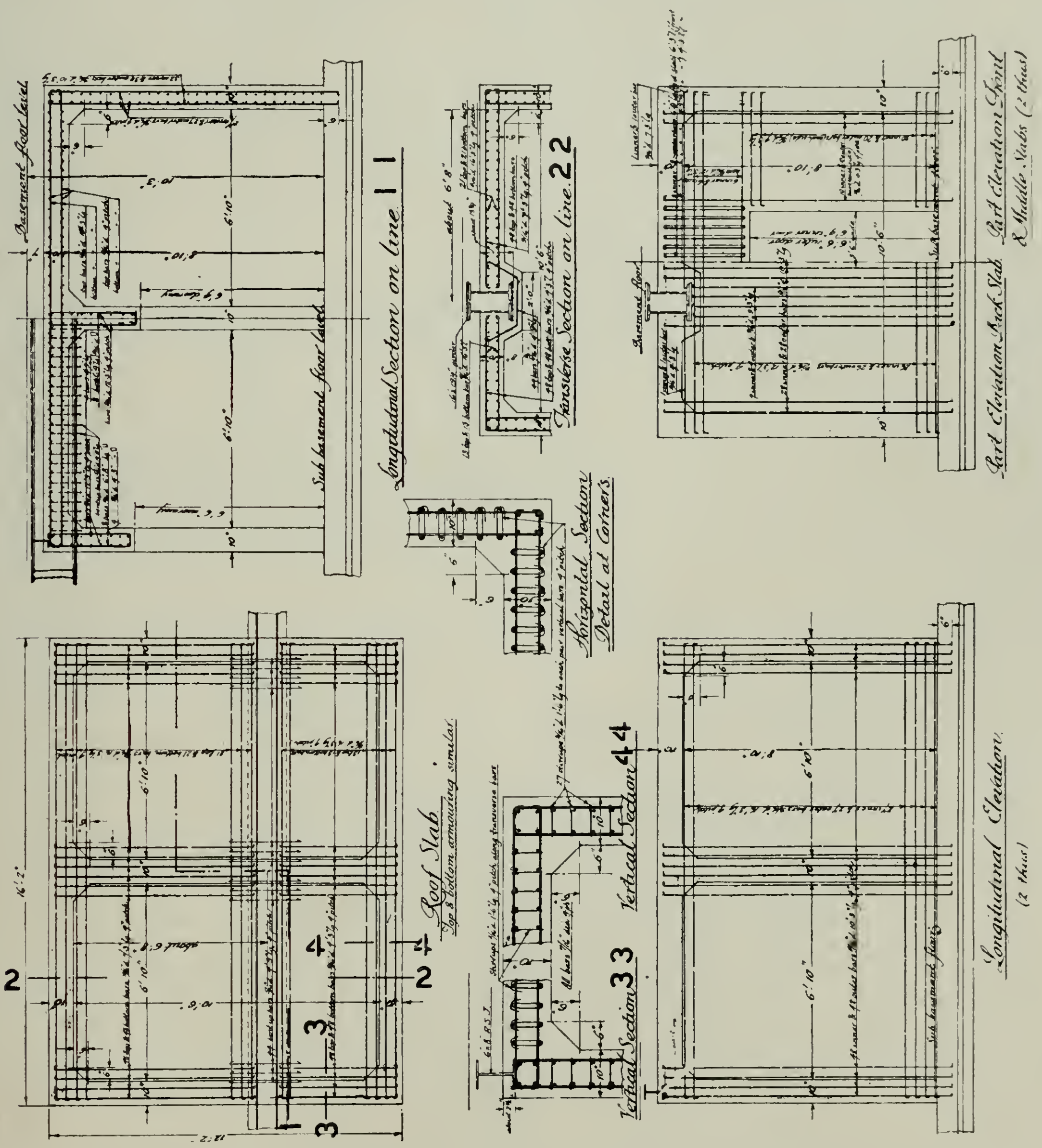

Basement floor level
Sub basement floor level
Longitudinal Section on line 1 1
Transverse Section on line 2 2
Part Elevation Back Slab
Part Elevation Front & Middle Slabs (2 thus)
Horizontal Section Detail at Corners
Roof Slab
Top & bottom armouring similar
Vertical Section 3 3
Vertical Section 4 4
Longitudinal Elevation (2 thus)
2
2
3
3
4
4

Fig. 7. Details of Construction of Strong Room in Sub-Basement.
Reinforced Concrete at the Royal Insurance Building.

of the reinforced concrete wall, which is only 21 in., a good comparison is offered between the relative advantages of the two materials. An asphalt damp course is provided on the outside of the wall on all faces.

The foundations to the steel stanchions are formed in reinforced concrete, the bases naturally varying in size according to the load. As a typical case, the largest is about 9 ft. 10 in. square at the bottom, with two offsets which reduce the size to 6 ft. 6 in. square and 4 ft. square. The first offset is formed at a height of 14 in. from the bottom, and the reduced sizes are each 8 in. deep, making a total thickness of 2 ft. 6 in.

The reinforcement consists of about 92 bars altogether, 44 of these being placed in the lower surface and the remainder as indicated on the drawing of this foundation, illustrated in *Fig.* 6. The different sets of rods are connected with stirrups as shown.

The strong room in a building of this description is a very important item, requiring to be burglar- and fireproof; and, in addition, it must possess sufficient strength to withstand the possibility of failure caused by other parts of the structure collapsing above and falling upon it. It is situated in the sub-basement floor, and is formed with reinforced concrete. The height is 8 ft. 10 in. in the clear, with two compartments each 10 ft. 6 in. by 6 ft. 10 in. between the walls, these two compartments having a division wall 10 in. thick, with a small doorway formed in same. The drawings are illustrated in *Fig.* 7, and it will be seen that the outside walls and roof are 10 in. thick, reinforced with vertical and horizontal bars in both inner and outer surfaces, the two sets being connected with diameter stirrups spaced at 4-in. centres.

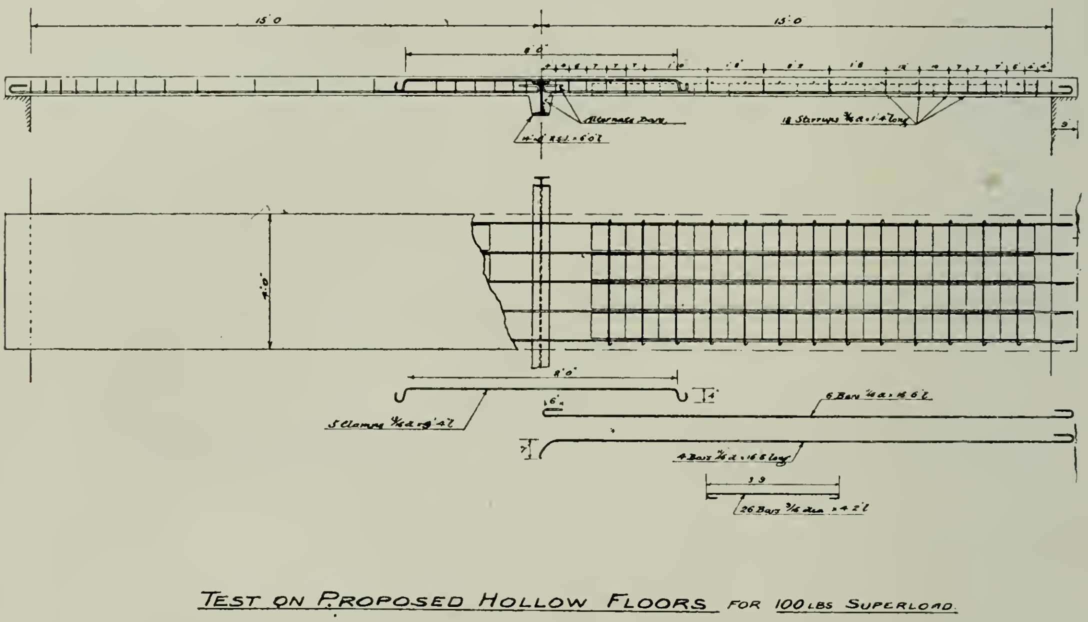


Fig. 8. Test on Hollow Floors.
REINFORCED CONCRETE AT THE ROYAL INSURANCE BUILDING.

The floor construction is carried out in reinforced concrete, lightened by the introduction of tiles. The latter are 9 in. by $4\frac{1}{2}$ in. hollow, with $2\frac{1}{2}$ in. of concrete above, giving a floor with a total thickness of only 7 in. The concrete was kept solid for a distance of 18 in. on either side of the steel joists which carry the sides of the bay, and the lower bars are carried into this and bent round. Bars are also carried over the top of the steel girders. The floor was required to carry a super-load of 100 lb. per sq. ft.; and two bays, having a span of 15 ft. each, were made for testing purposes before the floor was adopted by the architects.

The slabs were formed, and the centering was removed 15 days later, no props of any kind being left to support the work. The deflection immediately after the removal of the centering was about $\frac{1}{16}$-in., and this increased slightly in the course of a week, which seems to indicate that the concrete was still plastic

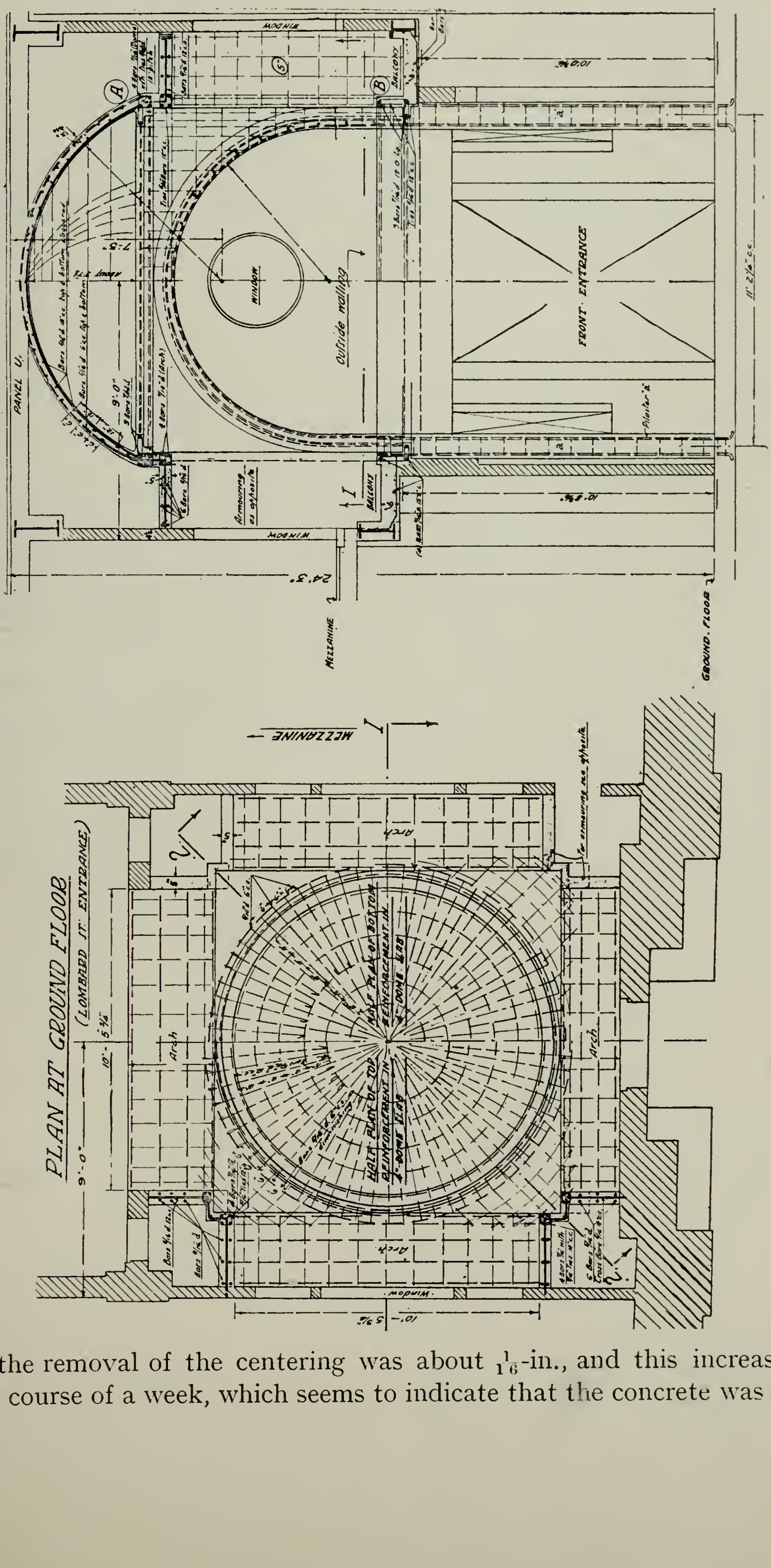


Fig. 9. Plan and Section of Dome over Main Entrance.
Reinforced Concrete at the Royal Insurance Building.

on the removal of the forms, the natural setting time of the cement having probably been delayed on account of some days' frost which occurred shortly after the slabs were formed.

The preliminary test was carried out twenty-four days after the construction of the slabs, and the load was applied by means of glazed bricks, which were stacked in twelve piles ranged in two rows along the slab with a 3-in. space between the piles. The load was applied until the amount per square foot was 154·2 lb., or $1\frac{1}{2}$ times the designed super-load, when the maximum deflection was ·282 in., and as the slabs were required for further experiment when the concrete was more seasoned, the loading was discontinued at this point. Cubes of the same concrete as that used in the test showed an increase of 48 per cent. in strength when tested ninety-eight days after mixing, as compared with that tested at twenty-two days old. The composition of the concrete was $7\frac{1}{2}$ cu. ft. of gravel, $3\frac{3}{4}$ cu. ft. of sand, and 1 bag of Portland cement. In making the final test on the same slabs, after maturing three months, the load was increased to 476 lb. per sq. ft., when the maximum deflection reached about ·99 in.; and, as the bricks were then sixteen courses high, it was impossible to record further deflections owing to the danger of the bricks falling.

The drawings in *Fig.* 9 illustrate the dome which is constructed over the Lombard Street entrance. This has a diameter of about 12 ft., the springing being about 17 ft. from the ground-floor level. It is formed with 4 in. of concrete strengthened with $\frac{5}{16}$-in. bars at 12-in. centres as circumferential reinforcement the bars in the top and under surfaces being staggered.

The radial bars are $\frac{5}{16}$-in. diameter, spaced at 6-in. centres at top and bottom. The dome itself is connected to reinforced concrete arches 5 in. thick, which are formed on four sides to convert the square plan in the circular form with reinforced concrete pendentives.

The reinforced concrete work was designed by the Considère Concrete Construction Co., Ltd., of 5 Victoria Street, Westminster, and executed by the contractors, Messrs. Trollope & Colls, of Coleman Street, E.C.

A PROBLEM IN DEFLECTIONS OF BEAMS.

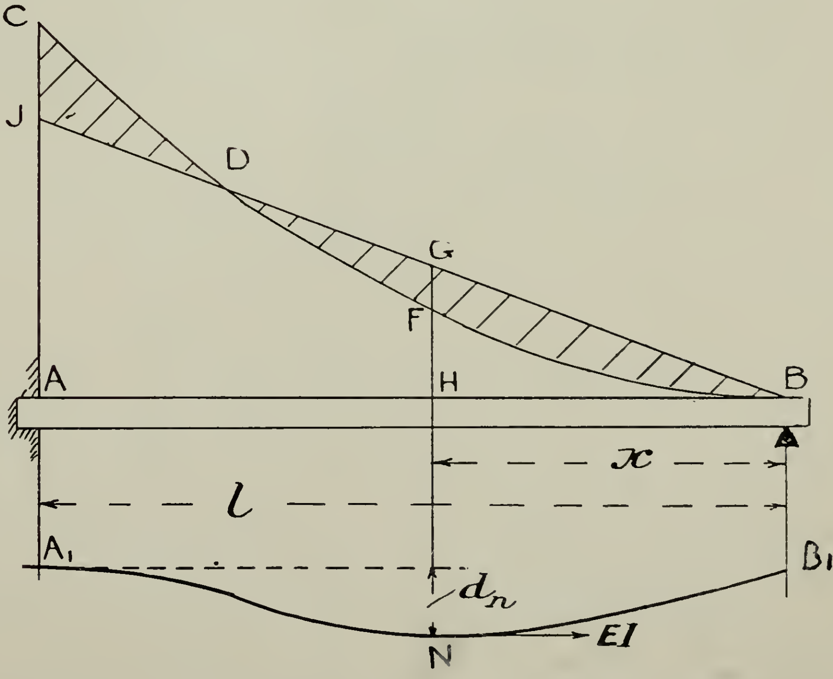
TO FIND THE MAXIMUM DEFLECTION FOR A UNIFORMLY LOADED BEAM FIXED AT ONE END AND SUPPORTED AT THE OTHER.

By EWART S. ANDREWS, B.Sc.Eng.(Lond.).

The following interesting contribution should appeal to many of our readers and lead to discussion. Our columns are open for replies.—ED.

THE determination of the maximum theoretical deflection in the above case is dealt with in very few of the text-books on the subject, and, as far as the writer knows, no publication has been made in which the problem has been solved without the use of the methods of the infinitesimal calculus. In the following investigation we will adopt the method of Mohr of considering the stability of an imaginary cable loaded with the bending moment diagram.

As will be found proved in the leading text-books on the subject, the bending moment diagram of a uniformly loaded beam of span l, fixed at one end, A, and simply supported at the other end, B, is as shown shaded in the figure; the curve BDC is a parabola of height $\frac{wl^2}{2}$ where w is the load per unit length of the beam, this being the B.M. diagram for the downward uniform load on the cantilever, and AJ is equal to $\frac{3wl^2}{8}$, JB being a straight line, this being the B.M. diagram for the reaction at B, which is $\frac{3wl}{8}$.



Our first problem is to find the point, N, at which the deflection has its maximum value. Consider the portion, $A_1 N$, of the imaginary cable.

The forces acting on it are a horizontal tension equal to EI at N (according to Mohr's Theorem), and an equal horizontal tension at the point, A_1 (since the beam must be horizontal at the fixed end, A); also an upward vertical force equal to the negative area, CJD, and a downward vertical force equal to the positive area, DFG.

If these forces are in equilibrium, since the horizontal forces are equal and opposite, the vertical forces are also equal and opposite, so that we get the following rule :

The maximum deflection will occur at the point where the area, D F G, is equal to the area, D J C.

This is the same as saying that the area, $A\ H\ G\ J$, is equal to the area, $A\ H\ F\ C$.

Now, if $HB = x$ and $AB = l$

$$\frac{HG}{x} = \frac{AJ}{l} \qquad \therefore \qquad HG = \frac{x\,AJ}{l}$$

$$\text{Area} \quad AHGJ = \frac{AH}{2}\left(AJ + GH\right)$$

$$= \frac{l-x.}{2}\ AJ\left(1 + \frac{x}{l}\right)$$

$$= \frac{(l-x)}{2}\ \frac{(l+x).}{l}\frac{3\,w\,l^2}{8}$$

$$= \frac{3\,w}{16}\left(l^2 - x^2\right) \qquad (1)$$

$$\text{Also Area } AHFC = \text{Area } ABDC - \text{Area } HFB$$

$$= \frac{1}{3}\,AC\,.\,AB - \frac{1}{3}FH\,.\,HB$$

$$= \frac{1}{3}\,\frac{w\,l^3}{2} - \frac{1}{3}\,\frac{w\,x^3}{2} \qquad (2)$$

If (1) = (2)

$$\frac{3\,w\,l}{16}\left(l^2 - x^2\right) = \frac{w}{6}\left(l^3 - x^3\right)$$

Factorising, we get

$$\frac{3\,w\,l}{16}\left(l + x\right)\left(l - x\right) = \frac{w}{6}\left(l - x\right)\left(l^2 + l\,x + x^2\right)$$

$\therefore$ dividing through by $\frac{w}{2}\left(l - x\right)$ and multiplying across we get

$$9\,l^2 + 9\,l\,x = 8\,l^2 + 8\,l\,x + 8\,x^2$$

$$\text{i.e.,} \qquad 8\,x^2 - l\,x - l^2 = 0 \qquad (3)$$

The general solution of this quadratic equation gives

$$x = l\,\frac{\pm\sqrt{l^2 + 32\,l^2}}{16}$$

$$= l\left(\frac{1 \pm \sqrt{33}}{16}\right)$$

The negative value is inadmissible

$$\therefore x = \frac{l\,(1 + \sqrt{33})}{16} = \cdot 422\,l \quad \text{nearly}$$

$\therefore$ *The maximum deflection occurs at a distance* = ·422l *from the simply-supported end.*

We now proceed to find the maximum deflection, d_m, by considering the stability of the portion, $N\ B$, of the imaginary cable.

The forces acting on it are a tension at B , the horizontal tension, $E\ I$, at N, and the area of the bending moment diagram, $B\ F\ G$.

By taking moments about the point, B_1, we eliminate the tension at this point and get $E\ I \times d_n =$ moment about B_1 of area, $B\ F\ G$.

Now, this area is made up of the difference between the $\Delta\ B\ H\ G$, and the parabola $B\ H\ F$.

The area of the $\Delta = \frac{1}{2}\ G\ H\ .\ B\ H = \frac{1}{2}.\frac{x\ A\ J}{l}.\ x$

$$= \frac{1}{2}\frac{x^2}{l}\cdot\frac{3\,w\,l^2}{8} = \frac{3\,w\,x^2\,l}{16}$$

The centroid of the Δ is at distance $\frac{2\,x}{3}$ from B

$$\therefore \text{ moment of } \Delta \text{ about } B_1 = \frac{3\,w\,x^2\,l}{16}\cdot\frac{2\,x}{3} = \frac{w\,x^3\,l}{8}$$

The area of the parabola $= \frac{1}{3}\ F\ H\ .\ B\ H$

$$= \frac{1}{3}\cdot\frac{w\,x^2}{2}\cdot x = \frac{w\,x^3}{6}$$

The centroid of the parabola is at distance $= \frac{3\,x}{4}$ from B

$$\therefore \text{ moment of parabola about } B_1 = \frac{w\,x^3}{6}\cdot\frac{3\,x}{4}$$

$$= \frac{w\,x^4}{8}$$

$\therefore$ moment about B_1 of area $B\,F\,G$

$$= \frac{w\,x^3\,l}{8} - \frac{w\,x^4}{8}$$

$$= \frac{w\,x^3}{8}\left(l - x\right)$$

$$E\,I \times d_n = \frac{w\,x^3}{8}\left(l - x\right)$$

putting $x = {\cdot}422\,l$

$$\therefore E\,I \times d_n = \frac{w \times {\cdot}422^3 l^3\ ({\cdot}578\,l)}{8}$$

$$= {\cdot}00543\,w\,l^4$$

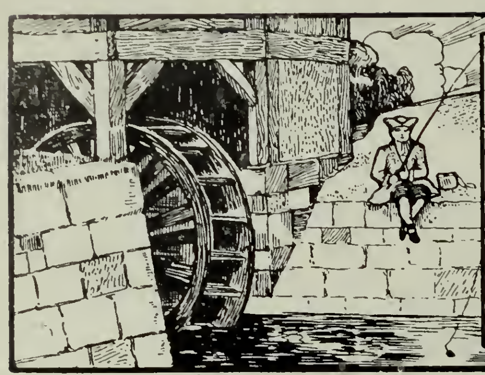
$$\therefore d_n = \frac{{\cdot}00543\,w\,l^4}{E\,I}$$

putting $w\,l$ = total load $= W$

$$d_n = \frac{{\cdot}00543\,W\,l^3}{E\,I}$$

$$= \frac{W\,l^3}{184\,E\,I}$$

For a uniformly loaded beam, simply supported at each end, we should get $d_n = \frac{Wl^3}{384\ E\ I}$, while for one similarly loaded, but fixed at each end, we should get $d_n = \frac{W\ l^3}{384\ E\ I}$, so that we see that in the case under consideration the deflection is between these two values. This is, of course, what one would expect.



CONCRETE SILOS.

(*Conclusion*)

By C. W. GAYLORD and PERCY H. WILSON, Assoc.M.Am.Soc.C.E.

The article below, the first part of which appeared in our preceding number, is taken from a very useful pamphlet issued by the Association of American Portland Cement Manufacturers, and should be of interest to all those carrying out concrete work on the farm.—ED.

Wooden Forms.—The face of the silo wall forms may be made of 1-in. tongued and grooved boards in place of the sheet metal shown in *Figs.* 7 and 8. In this case, in laying out the sawing of the circular 2 in. by 6 in. piece, shown in *Fig.* 6, make the length of string used for marking the inner circle 1 in. less, and the length of string used for marking the outer circle 1 in. more than shown. This is to allow for the 1-in. tongued and grooved face. Surfaced boards should be used and painted well with oil before the concrete is placed. Green lumber is preferable to dry lumber, as the latter absorbs moisture from the wet concrete and warps out of shape.

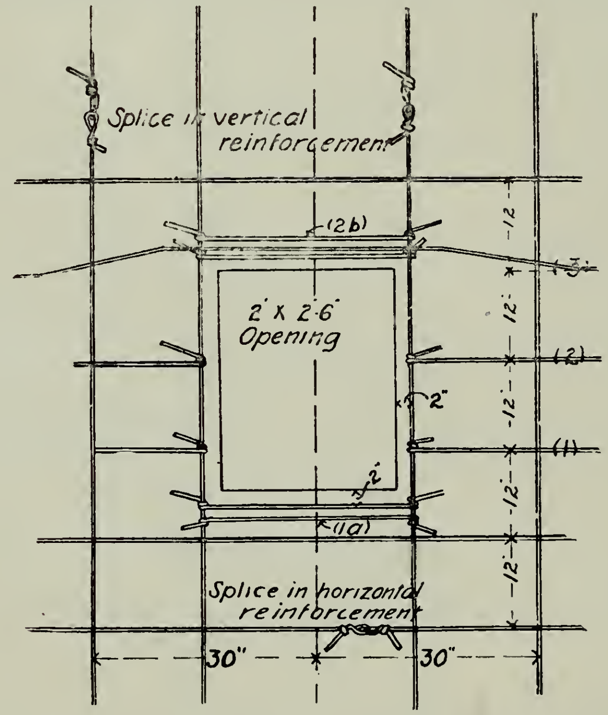

Splice in vertical reinforcement
(2b)
(3)
2' x 2'6" Opening
(2)
2"
(1)
2"
(1a)
12"
12"
12"
12"
12"
Splice in horizontal reinforcement
30"
30"

Fig. 12. Position of Reinforcement Around Door Opening.

The forms are now ready to be carried to the silo site and placed in the correct position on the footing for the first course of concrete. Set up the inside form first, and level it very carefully, putting in the hinge-bolts in the ends of section A, and the adjustment bolts between sections B and C. With the use of the spacing boards, shown in *Fig.* 7, place the outside form and then draw the upper and lower circle tight by means of the adjusting bolts. The spacing boards should be placed around the circle about every 3 ft. for the first trial.

Adjusting Bolts.—*Fig.* 5 shows the method of placing the adjusting bolts at the opening for both the inside and outside forms. For the inside form, the nuts on the adjusting bolts are on the inside of the opening between the 2 in. by 4 in. pieces which make the ends of the form. To contract the inside form, turn the nuts back to the centre. To expand the inside form, turn the nuts toward the ends of the bolts. The nuts on the bolts for the outside form are in back of the 2 in. by 6 in. pieces, which make the ends of the form and can pull the form together and hold it in place.

Place a piece of 1 in. by 12 in. by 3 ft. (two pieces of 1 in. by 6 in. by 3 ft. nailed together) back of the sheet metal across the openings, toe-nailing this piece to the sides or holding it in place with wedges between it and the adjusting bolts. This piece must be taken out and reset each time the forms are moved.

In placing the forms, remember to place the openings in the forms directly toward the side or point at which the hoisting of concrete is to be done when the silo wall gets above the ground. The openings have nothing whatever to do with the hoisting of the concrete, but right back of these openings will be two 3 in. by 6 in. posts, by means of which the hoisting is to be done.

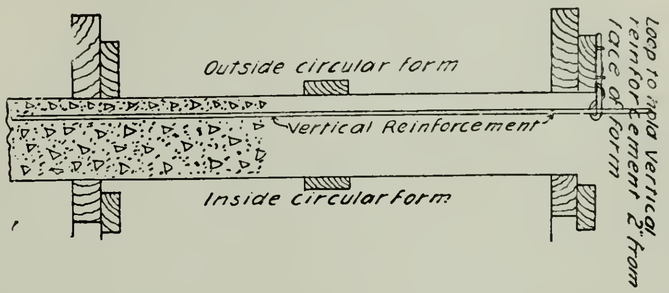


FIG. 13. LOOP TO HOLD VERTICAL REINFORCEMENT IN CORRECT POSITION WHILE PLACING CONCRETE.

Thickness of Walls.—The thickness of the silo wall can easily be increased over the 6 in. shown by setting the outside form farther away from the inside form and increasing its length slightly.

Placing Concrete for First Two Courses.—Everything is now ready for the placing of the concrete with the exception of placing the reinforcement. (Explained later.) As the second 3-ft. course of concrete only brings the top of the form 2 ft. above the groundline, both these courses and also the third should be placed by shovelling directly into the forms from the concrete board, or by dumping the wheelbarrow-loads directly into the forms if the mixing is being done at a distance from the site of the silo. Mix the concrete wet, so that it will need little tamping. Place it in from 4-in. to 6-in. layers and spade it thoroughly next to the forms.

Make each 6-in. layer of concrete level before starting a new layer. Before placing any concrete the concrete already in place should be carefully cleaned off by sweeping and then flushing with water. Then scatter a few handfuls of dry Portland cement over the old concrete. This should be done each time before starting to fill the forms after raising.

Fill the form flush with the top and carefully even off the edges. Rough up the centre of the top of the concrete as much as possible. This gives a good bond for the next course.

After the forms are filled with concrete place the scaffolding and arrange the form-lifting device, as shown in *Figs.* 7 and 8.

Form-lifting Device.—This consists of two pairs of 3 in. by 6 in. posts with a lever working between each pair. The 3 in. by 6 in. pieces can be bought in 12-ft. or 16-ft. lengths, and they can be made as long as desired by splicing them together on three sides with 2-in. strips (see *Fig.* 9). Joints in a pair should be broken at least

3 ft. The pairs of 3 in. by 6 in. should not be placed directly in line. This allows the levers to work past each other as shown in *Fig.* 8. For a 10-ft. silo they should be about 5 ft. apart. Increase this distance by 6 in. for every foot increase in the diameter of silos over 10 ft.

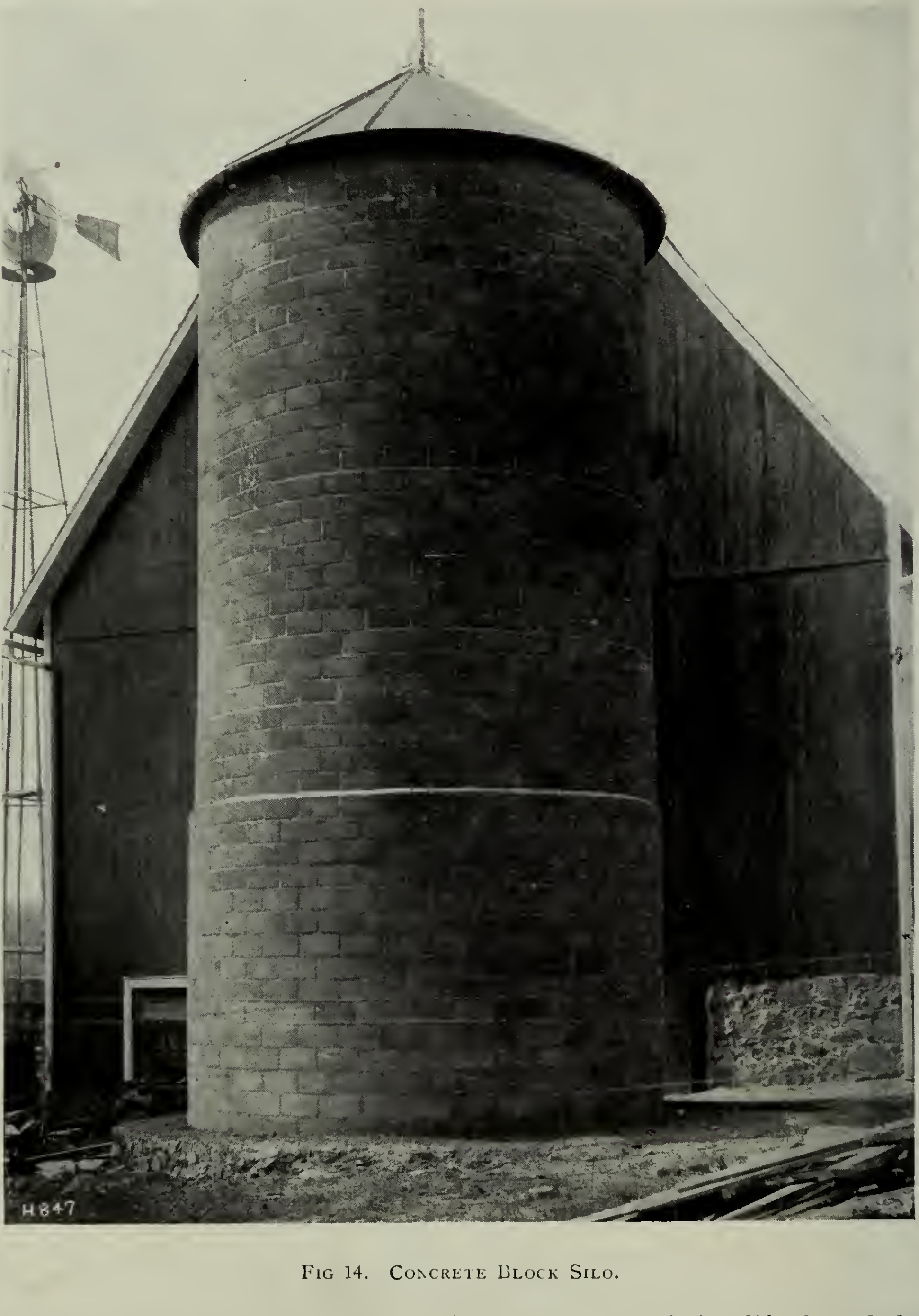


Fig 14. Concrete Block Silo.

These posts will be heavily loaded while the forms are being lifted, and should be erected as follows :

Lay two pieces of 2 in. by 12 in. planks across the floor of the silo on the line of the posts, taking a 12-ft. and a 16-ft. post to make up a pair. This prevents the splices from coming opposite each other. Place the posts in position, temporarily bracing them to the barn, if near enough, or to stakes in the ground outside the silo.

While this bracing is only temporary for the first 3-ft. course, it must be secure, and should be fastened to the post about 10 ft. from the bottom.

Securely fasten the lower ends of the posts with cleats to the 2 in. by 12 in. plank under them. Next place the 2 in. by 8 in. by 12 ft. lifting planks in place as shown in *Figs.* 7 and 8, and wire them securely at the four points where they each cross the forms, so as to allow about a 2-in. space between them and the forms when the wire is drawn tight. Use the size of wire given in Table C.

For the first lifting, wire the 2 in. by 8 in. lifting planks to the top circle of 2 in. by 6 in. pieces, as the bottom circle of 2 in. by 6 in. pieces rests on the concrete floor. Before making the second shift of forms, wire together the top and bottom circles of 2 in. by 6 in. pieces in both inner and outer form at the lifting point, so that the top circle will not have to take all the strain in lifting.

Measure on the posts 4 ft. above the top edge of the 2 in. by 8 in. lifting pieces and bore $1\frac{1}{16}$-in. to $1\frac{1}{8}$-in. holes through the posts.

After the first lifting of the forms, these holes bored in the posts to receive the lever bolts should be spaced the height of one section apart. Thus, if the 36-in. forms lap the finished wall by 4 in. a section of wall 32 in. high is built with each setting of the forms, and the holes should be spaced exactly 32 in., centre to centre. Space these holes carefully, as the wires to be described later will not be changed for the rest of the lifts.

Place the levers, made as shown in *Figs.* 7 and 8, between the posts and use a 1-in. bolt, 15 in. long, to fasten each lever between a pair of posts.

As the levers will only raise the forms 1 ft. at a time, three holds have to be provided in order to raise the forms 3 ft. This is done by making three loops of wire, each 1 ft. shorter than the other, by means of which the ends of the levers are attached to the lifting plank. The longest of the loops is just long enough to attach the lifting board to the lever, when the short end of the lever is in the lowest possible position, as shown in *Fig.* 8.

Three more loops of wire are attached to the lifting planks, just long enough to slip over the bolt in the uprights, and in this way hold the forms until the end of the lever can be attached to the second loop.

The shortest wire should hold the form about 1 in. higher than is finally desired. With the form held on the third or shortest loop, place two 2 in. by 8 in. braces under the form. These two pieces of 2 in. by 8 in. plank should be measured and cut to fit against the silo wall when they are nailed across the 3 in. by 6 in. posts. Level these braces carefully and nail them to the posts at a point just 4 in. below the top of the finished concrete in the walls.

Lay a straight edge across the top of the forms before lifting, and make a mark on the posts 4 in. below this edge. After the forms are raised, nail the two 2 in. by 8 in. braces to the posts, with the top edges at the mark. Brace the ends of the 2 in. by 8 in. planks with 1 in. by 6 in. boards, and further brace the posts whenever necessary as the work progresses, as shown in *Fig.* 8. With the weight of the forms on the levers, take off the loops over the bolt and lower the forms till the inside form rests on the 2 in. by 8 in. brace. Holding the levers in this position, expand the inside form into position with the adjusting bolts. Now lower the outside form in the same way, using the 6-in. spacing board to keep the two forms the correct distance apart at the top. Drive small wedges between the 2 in. by 8 in. by 12 ft. lifting pieces and the inside form so that the play in the wires between the 2 in. by 8 in. planks and the inside form will be taken up after the levers are released. These wedges will hold the 2 in. by 8 in. lifting pieces in place, and they in turn hold the outside form. The levers can now be released, and the form is again ready for concrete.

TABLE C.

Diameter of Silo in Feet.	Gauge of Wire for Slings—2 Strands to Each Sling.	Size of Lifting Piece.	Size of Horizontal Braces Under Form.†	Size of Lever. (Total Length over all is given.)
	Gauge No.*	in. in. ft.	in. in. ft. in.	in. in. ft. in.
10	10	2 by 8 by 12	2 by 8 by 8 6	2 by 6 by 7 6
11	9	2 ,, 10 ,, 12	2 ,, 8 ,, 9 0	2 ,, 6 ,, 8 6
12	9	2 ,, 10 ,, 12	2 ,, 8 ,, 9 6	2 ,, 6 ,, 9 0
13	9	2 ,, 12 ,, 12	2 ,, 8 ,, 10 0	2 ,, 6 ,, 9 6
14	8	2 ,, 12 ,, 12	2 ,, 10 ,, 10 6	2 ,, 6 ,, 9 6
15	8	2 ,, 12 ,, 14	2 ,, 10 ,, 11 0	2 ,, 6 ,, 10 0
16	8	2 ,, 12 ,, 14	2 ,, 10 ,, 11 0	2 ,, 6 ,, 10 6
17	8	2 ,, 10 ,, 14	2 ,, 10 ,, 11 6	2 ,, 6 ,, 10 6
18	8	2 ,, 10 ,, 14	2 ,, 12 ,, 12 0	2 ,, 6 ,, 11 0
19	7	2 ,, 10 ,, 16	2 ,, 12 ,, 12 6	2 ,, 6 ,, 11 6
20	7	2 ,, 10 ,, 16	2 ,, 12 ,, 13 0	2 ,, 6 ,, 11 6

Cautions.—As the work goes up be sure to brace the 3 in. by 6 in. posts securely. They will carry the weight of the forms easily enough, but not without proper bracing.

Do not raise the forms above the finished wall, as trouble will be experienced in getting them back in place.

Be careful to raise the forms slowly, and to work both levers at the same time in raising, so that the forms will be raised without binding.

Mix only two bag batches at a time, and place the whole batch before starting a new one.

Back-fill.—After the first three or four courses are placed, dirt should be filled in the hole next the concrete wall and carefully tamped, leaving the ground next to the silo wall a little higher than the surrounding ground.

HANDLING THE CONCRETE.

After the 3-ft. form has been used three times and is set in place for the fourth time, the top of the form will be 8 ft. above the ground outside the silo, and too high to shovel into. Therefore some method of hoisting the concrete must be used. The easiest way is to hoist the concrete in galvanised iron buckets or coal-scuttles. For the fourth course, the buckets can be handed up, but above that point they must be hoisted by a rope. For quick work it is best to rig up a block and fall and use a horse to do the hoisting, raising three or four buckets at one time. The block can be made fast to a 2 in. by 10 in. plank temporarily nailed to the four parts, as far above the forms as necessary, and extending out over the outside of the silo on the side where the mixing is done. If a horse is used, sink a short post alongside the silo directly under the overhead block. Fasten another block to the post near the ground and pull through it to one side. A single line is all that is necessary, as four ordinary buckets full of concrete will weigh only about 200 lb.

Caution.—In hoisting by horse or engine, as is sometimes done, the 3 in. by 6 in. posts must be well braced and guyed so that they will not be pulled out of plumb.

MIXING THE CONCRETE.

The concrete in silo construction should be carefully mixed. Concrete should be mixed wet, and the forms made tight to prevent the loss of any cement grout.

Footings and Floor.—The concrete in the footings and floor should be proportioned 1 : 3 : 6, which means 1 part Portland cement; 3 parts sand; 6 parts gravel or broken stone.

Walls.—The concrete in the silo walls should be proportioned 1 : 2 : 4, which means 1 part Portland cement; 2 parts sand; 4 parts gravel or broken stone.

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* American Steel and Wire Co.'s wire gauge used.

† The lengths of the braces in this column are only approximated for ordering lumber, and may be slightly varied.

SILO DOORS.

In the description of the erection of the silo walls no mention was made of the silo doors, openings for which must be left in the concrete walls. *Fig.* 10 is a vertical section through the silo, showing the arrangement of the silo doors. The doors are 2 ft. by 2 ft., and are spaced 3 ft. apart, starting at 1 ft. above the ground-line. Place these doors on the side of the silo nearest the feeding troughs.

Fig. 11 shows the construction of the silo door, with details. Make the doors of planed 2 in. by 6 in. or 2 in. by 8 in. tongued and grooved boards, held together by two 2 in. by 4 in. cleats, to which they are bolted with ⅝-in. bolts having round heads. The edges are all bevelled ½-in., as shown in *Fig.* 11. The doors are held in place by two ¾-in. round-headed bolts which pass through a 2 in. by 4 in. by 3 ft. 6 in. piece placed vertically on the outside of the silo wall. A gasket of tar-paper or similar substance is used between the wood door and the bevelled sides of the opening in the concrete, and by drawing up the bolts securely the door can be made absolutely

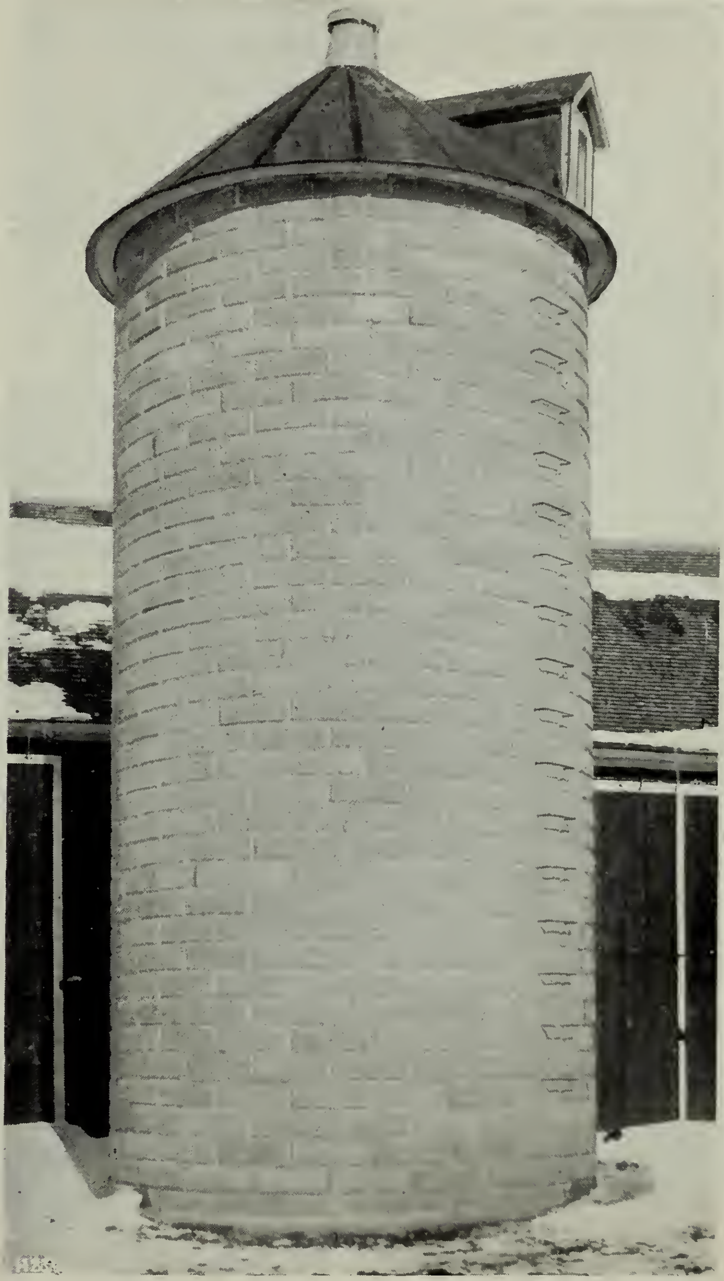


FIG. 15 SILO BUILT OF CONCRETE BLOCKS WITH DOUBLE AIR-SPACE.

air-tight. Care, however, must be used in planing the bevel edge of the doors in order to make a good fit. The lumber used for the doors should be the most durable wood obtainable, and should be planed on all sides. *Fig.* 11 is the same for all sizes of silos.

The form used for making the openings in the walls for the doors consists of a box open on the front and back, having straight sides and a curved top and bottom so that it will just fit between the silo forms. All the sides are bevelled. To place the door opening form inside the silo forms, bring the concrete up to about 1 in. higher than the level for the bottom of the opening. Have the concrete very soft, with an inch or so of mortar on top where the opening is to come. Shove the box form down into the concrete until it is at the right height and concrete around it, carefully spading the concrete along the sides of the box. A good plan is to mix up a little 1 to 2 mortar (1 part Portland cement, 2 parts sand) and keep placing it next to the box form as the concrete is placed ; 1 to 2 mortar should always be placed about $\frac{1}{2}$ in. to $\frac{3}{4}$ in. thick over the top of the box form. On account of the spacing of the doors, the opening will not always come all in one 3-ft. height of silo forms. In this case leave the box form in place and raise the silo forms as if it were not there. Care should be taken in

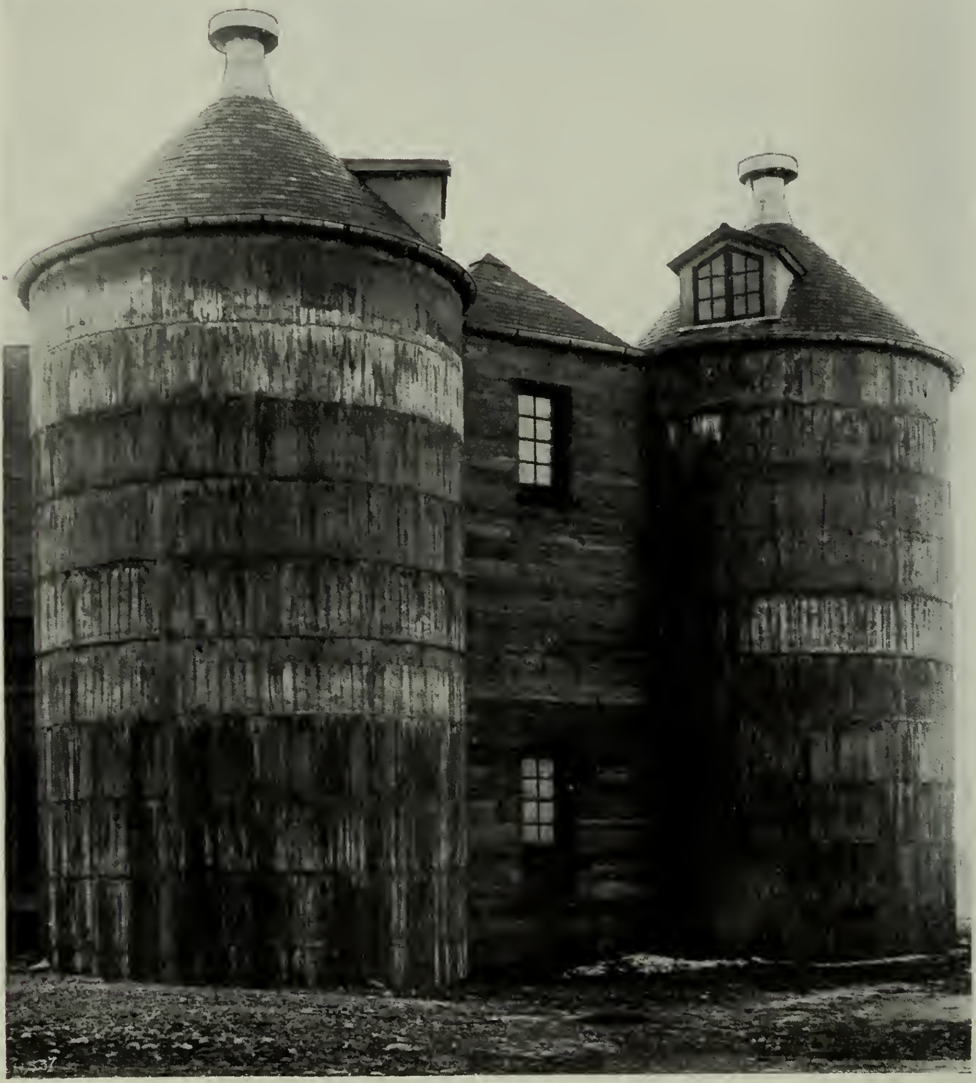


FIG. 16. CONCRETE CHUTE BETWEEN TWO SILOS.

this case to clean away the old mortar from the sides of the box above the form in order to make a good bond at this point.

There must be two of these box forms made, and each should be left in place until absolutely needed again, as this allows the concrete over the opening to harden before the box is removed. Before using these boxes should be carefully painted with a couple of thin coats of black or cylinder oil. They should be wiped off before using, and when not in use should be kept out of the sun to prevent warping.

LADDER AND CHUTE.

The ladder up the side of the silo alongside the doors can be made in many ways.

Bend round bars into shape and place them into holes in the concrete, afterwards filling any space around the bars with cement mortar. The holes in the concrete can be formed by wedging a tapered wooden plug, slightly larger than the round iron, across the forms in the position where you wish the hole to come. If the plug be well oiled it can be driven out, but if it sticks to the concrete it can be burned out with a hot iron.

In many localities it is found most convenient to have a chute surrounding the silo doors.

These chutes are sometimes made of concrete, and *Fig.* 16 shows two concrete silos, with a concrete chute between. Where a roof is placed over the chute it is well to have one or two windows in it.

REINFORCEMENTS.

The correct reinforcing of the silo walls with small steel bars or steel wire must be done with accuracy and care, as the strength of the silo depends on the correct use of steel in the walls. The silo walls are reinforced in two directions—vertically and horizontally. The vertical reinforcement consists of tie rods running from the top of the walls down into the footing. The horizontal reinforcements are hoops.

Since the pressure in a silo increases with the depth, it is necessary to make the walls much stronger at the bottom than at the top. The same amount of reinforcement is always necessary for sections of walls of equal distance from the top of the silo, in all silos of the same diameter, regardless of the total height. In no case should the horizontal wires or bars be placed over 18 in. apart or the vertical bars or wires placed over 36 in. apart.

How to Place Steel Reinforcement.—The placing of the reinforcement is a very simple matter, but there are several points of importance to be noted.

1. To tie reinforcement to prevent slipping. The horizontal reinforcement should be cut in one length, if wire, and the ends looped together and twisted back. If bars are used, the ends should be bent around each other at each lap. The extreme ends of the vertical reinforcement should be tied by bending around four extra strands of the largest wire used, two wires being placed 2 in. below the top of the silo wall, and the other two in the centre of the silo footings.

The vertical rods should be placed in short lengths, as it is very hard to handle the forms with rods running the entire height of the silo. These short lengths can be twisted or spliced together as the wall is built up.

In starting the vertical reinforcement in the footing use only 2 ft. 6 in. or 3 ft. lengths, taking 6 in. to twist around the two horizontal tie rods or wires placed in the centre of the footings. This will leave 1 ft. 6 in. to 2 ft. to stick above the finished footings.

The next section of vertical reinforcement is tied to these short lengths, and they will not interfere with the setting of the concrete forms.

2. To place reinforcement around doors and openings.

Fig. 12 shows how the reinforcement is placed around the door openings. In the section of wall used the horizontal reinforcement is placed 12 in. apart and the vertical 36 in. apart. The dotted line about the middle of the opening shows where the vertical wire would have come. As it is desired to always have a vertical rod or wire not over 3 in. away and on either side of the line of doors, two verticals have to be substituted for the one omitted. Where the horizontal wires or bars numbered (1) and (2) in

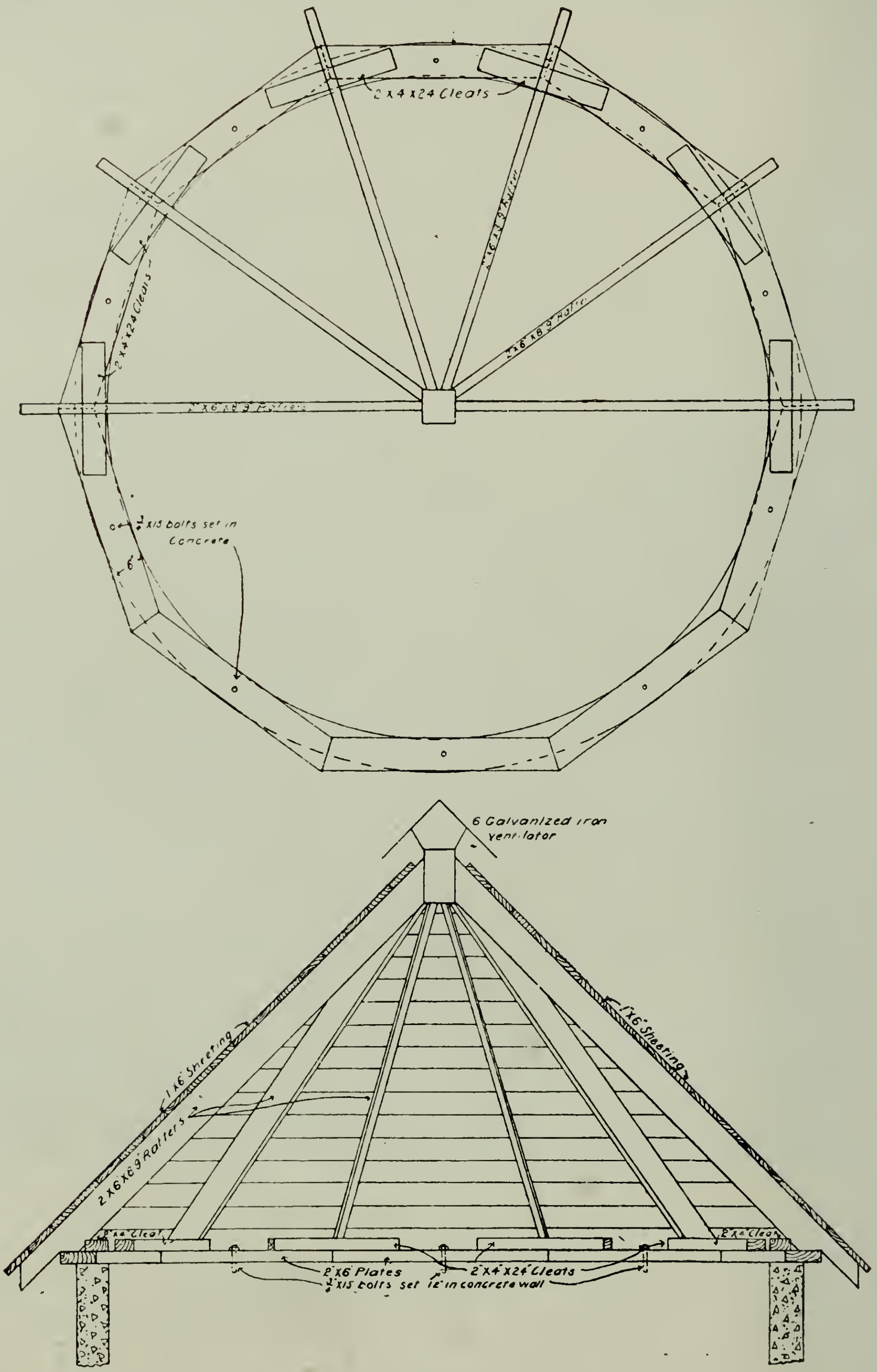


Fig. 17. Details of Roof.

Fig. 12 would run across the opening some distance from the top or bottom, fasten them to the verticals next to the opening, as shown. Cut short pieces of wire and place them at (1*a*) and (2*b*) to take the place of (1) and (2). The horizontal short wire 2 in. above and below the opening is always placed regardless of where the horizontal reinforcement comes. Wire marked (3) comes near enough to the top of the opening to be bent up and over it without cutting and using an extra short piece. In order to hold the rods in place, bend a piece of wire as shown in *Fig.* 13, and hook it over the outside of the form.

3. The horizontal hoop reinforcement should be on the outside of the vertica reinforcement and about 2 in. from the face of the outside form.

ROOF OVER SILO.

A roof is essential to a good silo in order to keep the snow out and to prevent the silage from freezing. *Fig.* 17 shows how a cheap, substantial roof can be built. Set $\frac{3}{4}$ in. by 15 in. bolts 11 in. down into the form on the last filling so that they will stick out 4 in. above the top of the wall. The plate, which is made of 2 in. by 6 in. pieces cleated together with 2 in. by 4 in. cleats, is held in place by these bolts. This plate can be laid out on the ground and the pieces cut and put together on top. Give enough pitch to the roof to shed snow. The roof shown in *Fig.* 17 is pitched 45 degrees. Build an ordinary trap-door between two of the 2 in. by 6 in. rafters on the side from which the silo is to be filled.

PATCHING.

If on raising the forms open spaces between the stones are found, due to carelessness in spading or on account of a leak in the form, these places should be patched at once. First remove all the loose pebbles and rough up the surface to get a good bond. Then fill the hole with a 1 to 2 Portland cement mortar, making the outside flush with the rest of the surface. If patched at once and then painted later on with cement grout, the place will not be noticeable. Be careful not to let the patched place dry out more rapidly than the surrounding concrete. This can be prevented by wetting every day with water applied by means of a whitewash brush.

PAINTING THE SILO.

As before explained the inside of a silo should be as smooth as possible, to permit the silage to settle evenly.

As the wall is built slight rough spots are sometimes left, due to concrete sticking to the forms. These can be easily made smooth by applying a coat of cement mortar, consisting of one part Portland cement and one part fine sand, mixed with water to the consistency of cream. Apply this with a whitewash brush. Before applying, brush the wall thoroughly with a dry, stiff brush. Then wet the wall, and then apply the wash, while the wall is still wet. Stir your cement and sand mixture constantly while applying. If this is not done the cement and sand settle to the bottom, and you will be painting your wall with water only. Mix this grout in very small quantities and put on a thin and not a thick coat over both the inside and outside of the silo.

This treatment not only makes a smooth wall, but also tends to make it waterproof.

Another method of waterproofing consists in drying the walls thoroughly and cleaning with a wire brush. Then paint with a hot solution consisting of three pounds of castile soap dissolved in four gallons of water. Use a kalsomine brush for the paint and do not boil the solution or let it froth while applying. After twenty-four hours' drying apply a second solution, consisting of a cold solution of $\frac{1}{2}$ lb. of alum to 4 gallons of water. This should make even poorly mixed and placed concrete air- and watertight.

CEMENT OR CONCRETE BLOCK SILOS.

Concrete blocks are made in two ways—hollow and solid. Practically all silos are built of hollow blocks. The blocks may be made by the farmer himself, or he may buy them from a block manufacturer. If the blocks are bought care must be taken to secure well-seasoned ones. That is, the blocks must have been made a sufficient time before using to give them time to thoroughly set.

Fig. 14 shows a concrete block silo in Jackson, Mich. It is 35 ft. high and 14 ft. inside diameter. The blocks for the lower third of the height are 8 in. high by 10 in. thick by 16 in. long ; the blocks in the upper two-thirds are 8 in. high by 8 in. thick by 16 in. long. Every third course is reinforced with a $\frac{1}{2}$-in. round iron embedded in grooves in the block. The blocks are laid in cement mortar, made in the proportion of 1 part Portland cement to 2 parts sand.

The silo shown in *Fig.* 15 is built of concrete blocks with a double air-space laid in cement mortar. It is reinforced with rods running through the grooves in both directions.

Many successful concrete silos have been built by methods other than those described, but for one who does not know how to handle concrete the best results will be obtained by following closely the methods described herein.

TESTS ON A REINFORCED CONCRETE TELEGRAPH POLE.

The following account of some extremely interesting tests carried out on a reinforced concrete telegraph pole merits careful attention from our readers and from the public authorities concerned with the erection of telegraph and telephone poles.—ED.

TESTS ON A REINFORCED CONCRETE TELEGRAPH POLE AT THE WORKS OF THE BRITISH IMPROVED CONSTRUCTION CO., LTD.

SOME very important tests on a telegraph pole, 38 ft. 6 in. elevation from the ground, were carried out on October 10th, 13th and 16th last at the company's works at Stevenage Road, Fulham, in the presence of representatives of the Post Office, London & North Western Railway and others.

The length of the pole over all was 44 ft. 6 in., of square hollow section, 17 in. square outside at the base, and 13 in. square inside at the same point, while the outside and inside dimensions at the top were 8 in. and 4 in. respectively. The reinforcements consisted entirely of 248 $\frac{3}{16}$-in. diameter high-tension steel wires, with an ultimate tensional stress of 80,000 lb. to 85,000 lb. per sq. in., 56 wires being assembled together in each corner. These wires were held together by $\frac{11}{16}$-in. by $\frac{1}{16}$-in. mild steel-wire plates pitched about 2-ft. centres. No binding wires whatever were used in the construction of the reinforcement. The pole was firmly embedded in concrete for 5 ft. 6 in.

On Tuesday, October 10th, the pole was tested up to $35\frac{1}{2}$ cwt., when the crab was found to be insecure, so test was discontinued. It was continued on Friday, October 13th. A slight hair crack was observed on tension side about 5 ft. 6 in. above surface of foundation when load was $33\frac{1}{2}$ cwt.

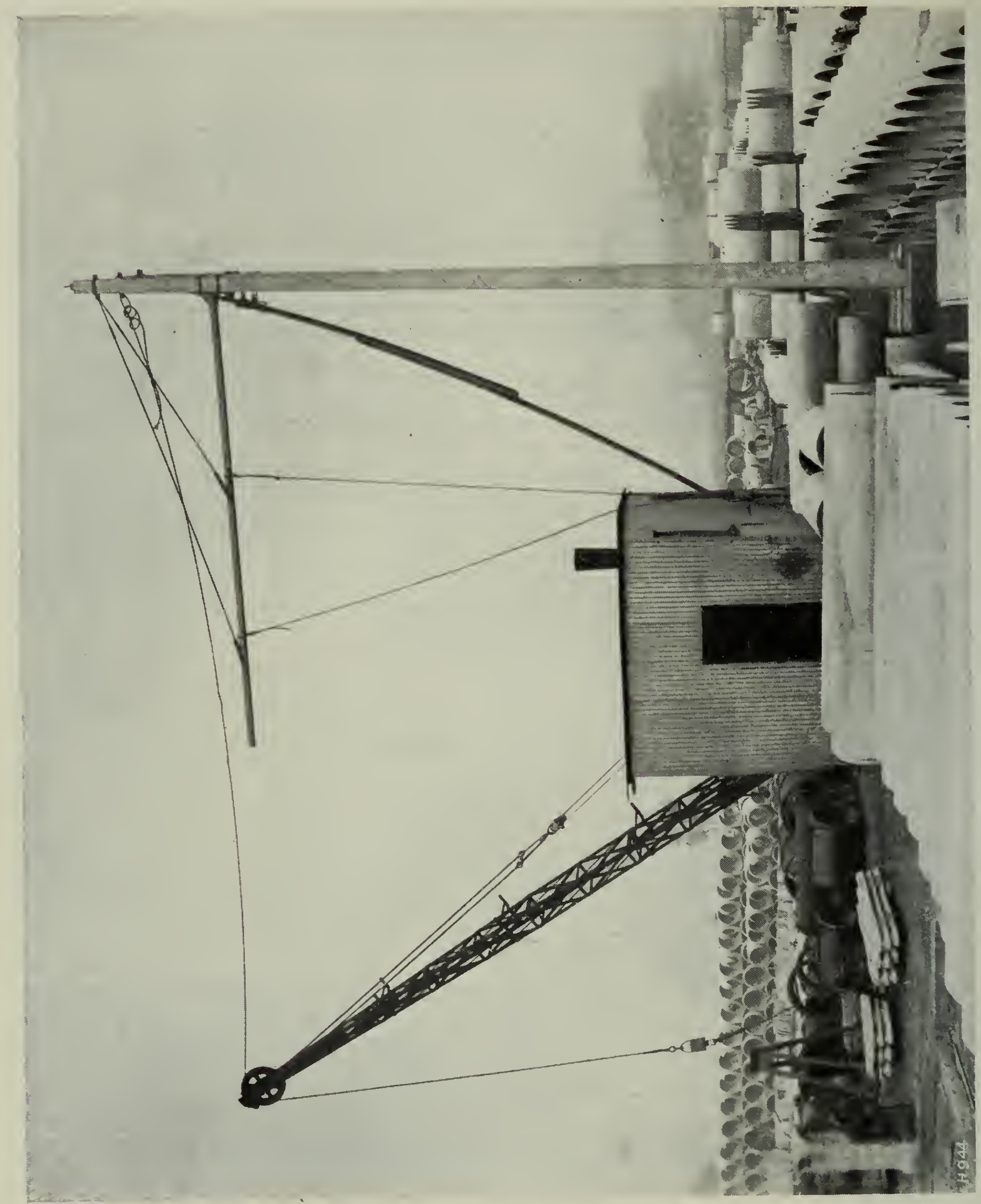
When load was 36 cwt., slight hair cracks appeared pitched regularly about 8 in. to 9 in. apart. At 41 cwt. a slight shear crack appeared, starting at 33 in. above foundation, and extending vertically at a distance of 2 in. from tension side for 3 ft. 6 in. in length.

At 46 cwt. hair cracks on tension side occurred regularly every 3 in. or 4 in. At 51 cwt. cracks on tension side were noticed to be travelling across sides of pole to within 6 in. of compression surface.

At 61 cwt. shear crack was more pronounced, and hair cracks on tension side occurred pitched about 1 in. centre. No signs of failure were observed on compression side at 61 cwt., and this being the limit of gauge on testing apparatus, the test was discontinued.

On October 16th the test on pole was continued, with the following results :

At 94 cwt. the pole had a deflection of 68 in., and cracks on tension side and shear cracks were more numerous and pronounced. No signs of failure on the compression side were observed. Load was released, and pole was found to have a permanent set of 21 in.



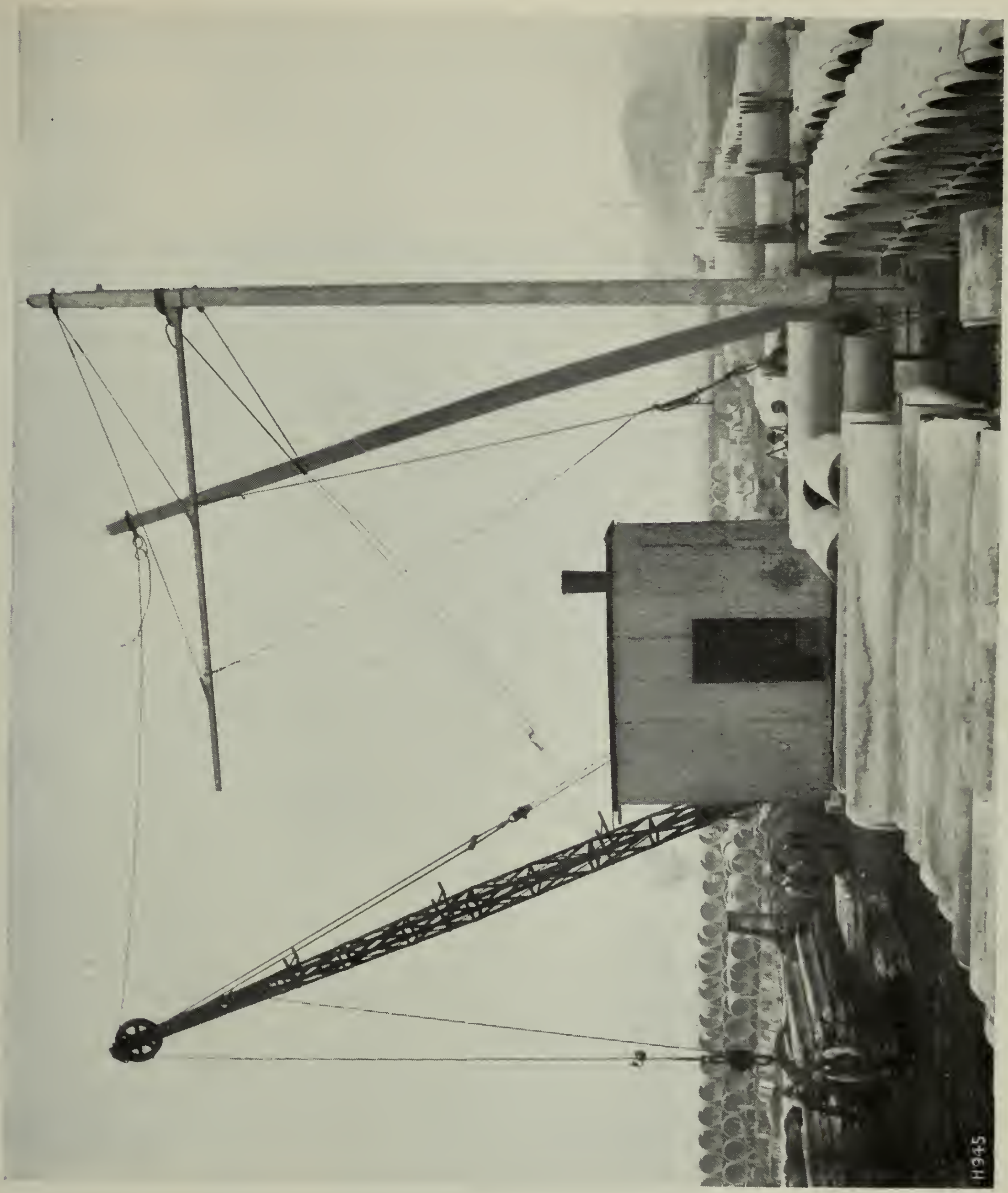
View of Pole before Load was Applied.

Tests on a Reinforced Concrete Telegraph Pole.

Load was again applied, and with a deflection of 73 in. the first signs of failure on compression side were noticed at surface of foundation. Load was still further applied, when, with a deflection of 78 in., the pole completely failed on compression side.

On examination after test, the pole was found to have failed almost equally for its whole length both on tension and shear sides, no signs whatever of local weakness being evident. On compression side pole showed signs of failure only from base to about 2 ft. up.

Total bending moment at base of pole	4,863,936 in. lb.
Area of steel at base	6·84728 sq. in.
Area of concrete	106 sq. in.



View of Pole after Destruction.

TESTS ON A REINFORCED CONCRETE TELEGRAPH POLE.

PARTICULARS OF TEST HELD ON OCTOBER 10TH, 1911.

Test No.	Load in cwt.	Deflection in in.	Permanent set in in.
Test No. 1	3	$\frac{3}{4}$	—
,, No. 2	5	2	—
,, No. 3	10	$4\frac{1}{4}$	—
,, No. 4	$12\frac{1}{2}$	5	—
,, No. 5	15	$6\frac{1}{4}$	—
,, No. 6	$17\frac{1}{2}$	8	—
,, No. 7	20	9	—
,, No. 8	$22\frac{1}{2}$	$10\frac{1}{2}$	—
,, No. 9	25	12	$\frac{1}{4}$
,, No. 10	$27\frac{1}{2}$	14	$\frac{1}{2}$
,, No. 11	30	$14\frac{3}{4}$	$\frac{5}{8}$
,, No. 12	$35\frac{1}{2}$	$19\frac{1}{2}$	$\frac{3}{4}$

To above weights must be added 1 cwt. for weight of spring balance, chain, etc.

Method of Testing.—A wire rope was firmly attached to a clip round top of pole, and carried over the pulley sheave on crane jib at approximately the same level as top of pole. Wire was then carried down to within about 10 ft. of ground and a

Salter spring balance (Type 99—3 ton graduated in ½-cwts.) attached; a chain was then attached to spring balance and wound on the drum of a 2-ton geared crab winch.

After each test the load was released, and permanent set registered.

The pole was firmly embedded in concrete for 5 ft. 6 in., and load was applied 38 ft. 6 in. above top of concrete foundations.

Dimensions of Pole (hollow)—

Length over all ... 44 ft. 6 in.
Size at top... ... 8 in. square outside and 4 in. square inside.
Size at base ... 17 in. square outside and 13 in. square inside.

PARTICULARS OF TEST HELD ON OCTOBER 13TH, 1911.

	Load in cwt.	Deflection in in.	Permanent set in in.
Test No. 1	31	16½	½
,, No. 2	32	17½	⅝
,, ,,	33	18	
,, ,,	34	18¼	
,, ,,	35	18¾	
,, No. 3	34	19	¾
,, ,,	35	19½	
,, ,,	37½	21⅜	
,, ,,	40	22	
,, No. 4	41	23½	1⅛
,, ,,	42	23¾	
,, ,,	42½	24	
,, ,,	44	25	
,, ,,	45	25½	
,, No. 5	46	26½	1¾
,, ,,	47½	27¼	
,, ,,	48	28¼	
,, ,,	49	28½	
,, ,,	50	29	
,, No. 6	51	30	When the load was 57½ cwts. with 34 in. deflection, the chain on drum of winch broke, releasing pole suddenly. Pole flew back, and after vibrating violently for a few seconds regained its normal position, and on examination it was found that no permanent set was indicated.
,, ,,	52	30¾	
,, ,,	52½	31	
,, ,,	54	32	
,, ,,	55	32½	
,, ,,	57½	34	
,, No. 7	42	27	2 in.; permanent set when measured 1 hour 30 min. after test was found to be 1/16 in.
,, ,,	44	28	
,, ,,	46	29	
,, ,,	48	30	
,, ,,	49	31	
,, ,,	52	32	
,, ,,	53	33¼	
,, ,,	54	33½	
,, ,,	55	34½	
,, ,,	56	34¾	
,, ,,	57	35¼	
,, ,,	58	36	
,, ,,	58½	36½	
,, ,,	59	37	
,, ,,	59½	37½	
,, ,,	60	37½	

To above weights must be added 1 cwt. for weight of spring balance, chain, etc.

Method of Testing.—A wire rope was firmly attached to a clip round top of pole, and carried over the pulley sheave on crane jib at approximately the same level as top of pole. Wire was then carried down to within about 10 ft. of ground, and a Salter spring balance (Type 99—3 ton graduated in ½ cwts.) attached; a chain was then attached to spring balance and wound on the drum of a 5-ton geared crab winch.

After each test the load was released, and permanent set registered.

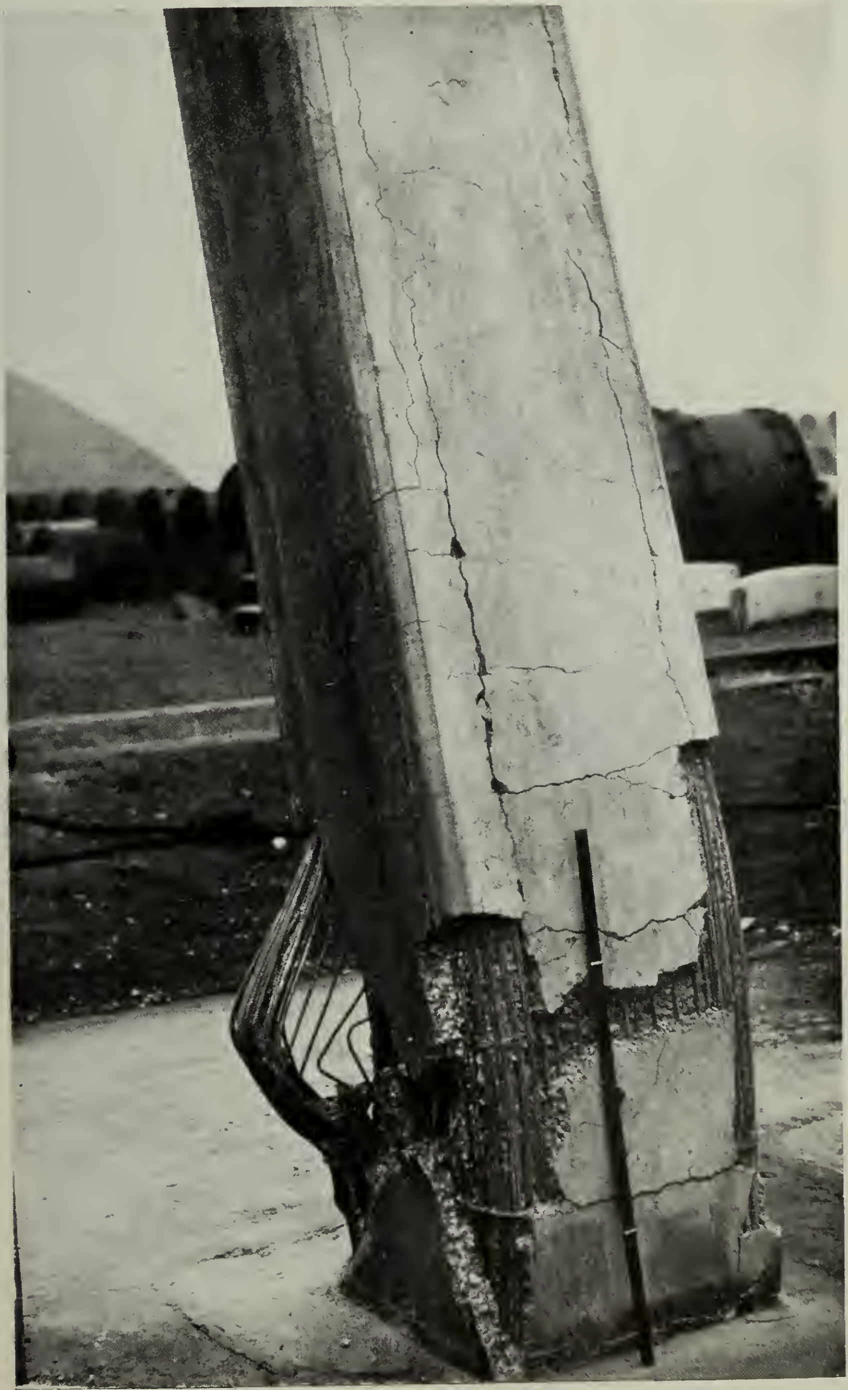
Pole was firmly embedded in concrete for 5 ft. 6 in., and load was applied 38 ft. 6 in. above top of concrete foundations.

Dimensions of Pole (hollow)—

Length over all ... 44 ft. 6 in.
Size at top ... 8 in. square outside and 4 in. square inside.
Size at base ... 17 in. square outside and 13 in. square inside.

PARTICULARS OF CONTINUATION OF TEST HELD ON OCTOBER 16TH, 1911.

	Load in cwt.	Deflection in in.	Permanent set in in.
Test No. 1	20	9	21
,, ,,	40	22	
,, ,,	60	31	
,, ,,	70	36	
,, ,,	75	39	
,, ,,	80	42½	
,, ,,	85	47	
,, ,,	90	56	
,, ,,	92	66	



Tension Side of Broken Pole.

TESTS ON A REINFORCED CONCRETE TELEGRAPH POLE.

TEST NO. 2.

The load was again applied, and when pole deflected 73 in. the first signs of failure on compression side were observed just at surface foundation.

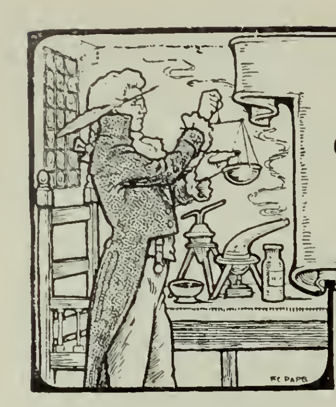
Load was still further applied until 78 in. deflection, when pole failed completely on compression side.

To above weights must be added two cwts. for weight of spring balance, chain, etc.

Method of Testing. — A wire rope was firmly attached to a clip round top of pole, and carried over the pulley sheave on crane jib at approximately the same level as top of pole. Wire was then carried down to within about 10 ft. of ground and a spring balance (12 ton—graduated in cwts.) attached; a chain was then attached to spring balance and wound on the drum of a 5-ton geared crab winch.

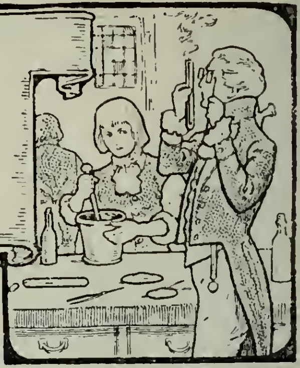
After each test the load was released, and permanent set registered.

The pole was firmly embedded in concrete for 5 ft. 6 in., and load was applied 38 ft. 6 in. above top of concrete foundations.



THE ELECTROLYTIC CORROSION OF STEEL REINFORCEMENT

By CECIL H. DESCH, D.Sc., Ph.D.



The problem of electrolysis has been accorded special attention recently in the American technical press, and the following article on these investigations and the conclusions to be obtained therefrom should prove of interest. Mr. Harold P. Brown kindly put the photographs at our disposal. Most of them originally appeared in "Engineering News."—ED.

THAT steel reinforcement embedded in well-made concrete is almost perfectly safeguarded against atmospheric corrosion has long been thoroughly established, and the fact is recognised by all engineers. In spite of this, injury of an unexpected kind to reinforced concrete structures has recently been observed in several instances, the injury being due in the first place apparently to corrosion of the steel reinforcement. Suspicion fell on stray electric currents as the cause, and the investigation of the conditions has already led to interesting and important results.

Electrolytic Corrosion.—The effect of stray currents on iron or steel embedded in the earth is already familiar to municipal and other engineers, the effect being particularly troublesome in the case of water pipes. At places where current leaves the pipe to enter the surrounding earth, pitting of the metal takes place, and may proceed as far as actual perforation. This is naturally most liable to occur in the immediate neighbourhood of electrical generating stations, but it may also occur at a distance from them, where cables or tramway rails are laid near to water mains. Further, several mysterious cases of corrosion of brass condenser tubes have been traced to the leakage of current from neighbouring electrical generating plant through the metal of the condenser into the sea-water used for cooling. It might be thought that steel enclosed in concrete would be sufficiently protected from influences of this kind, but recent experience shows that under certain circumstances the reinforcement is actually exposed to a serious and hitherto unsuspected danger. Fortunately, the observations and experiments that have been made point to the means of avoiding such accidents in the future.

Instances of Corrosion.—The principal instances of serious corrosion that have been described in detail are the girders, beams and columns of a large reinforced concrete packing warehouse in New York, investigated and described by Mr. Harold P. Brown in *Engineering News*; and a quay and jetty at Southampton, investigated by a committee composed of Messrs. H. K. G. Bamber, C. F. Marsh and F. S. Wentworth-Sheilds, and described by them in a report to the Concrete Institute.

Laboratory Investigations.—Mr. Harold Brown, in the investigation above referred to, conducted some laboratory experiments in order to elucidate the nature of the electrolytic process. In addition, two series of experiments have been described and the results communicated to the American Institute of Electrical Engineers during the present year: one by Messrs. C. E. Magnusson and G. H. Smith, of the University of Washington; and the other by Mr. H. Barker and Prof. W. L. Upson, of the University of Vermont. All these communications have been reproduced or abstracted in recent engineering periodicals.

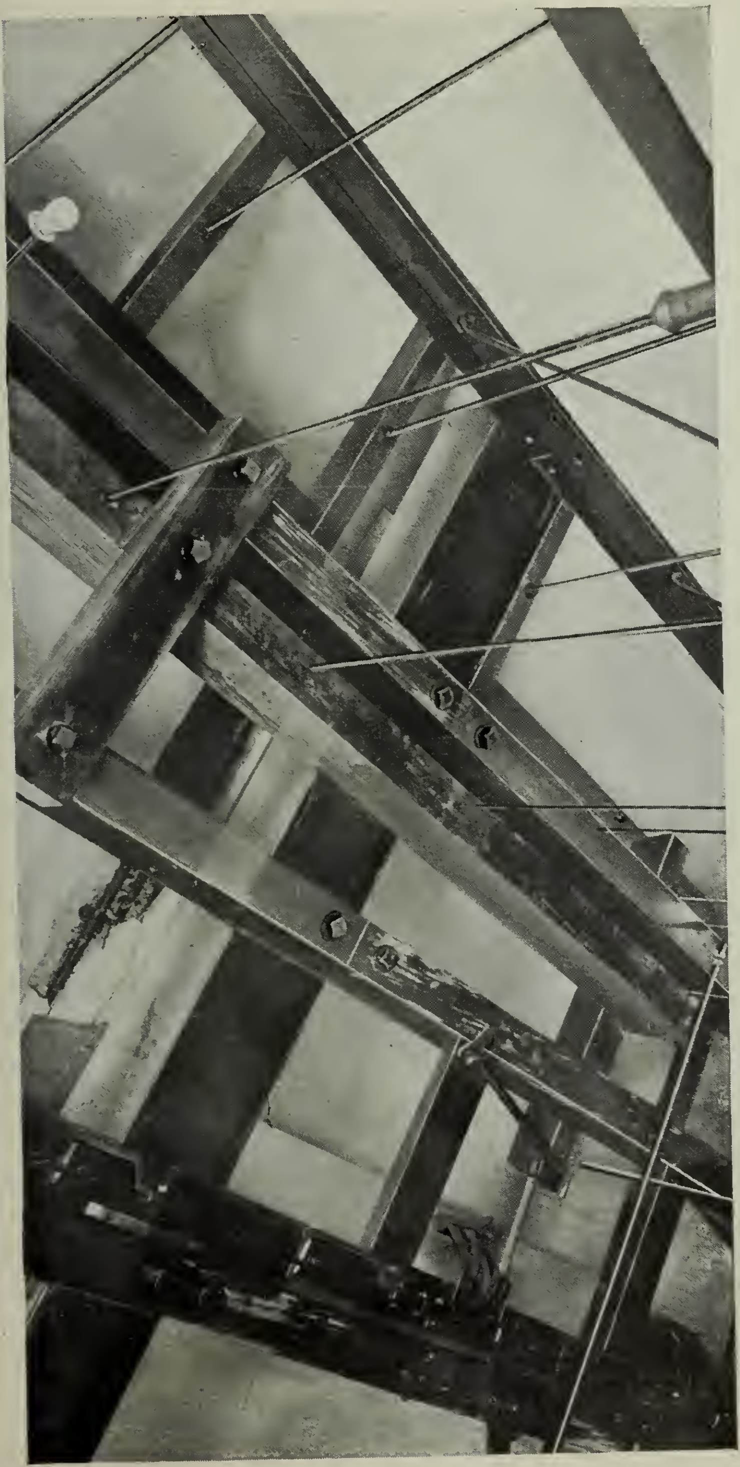


Fig. 1. View of Ceiling showing exposure of rods in a beam.

THE ELECTROLYTIC CORROSION OF STEEL REINFORCEMENT.

Symptoms of Damage.—The external signs of damage are very similar in each case, deep cracks appearing in the concrete, extending as far as the reinforcement. Sometimes the cracking is so extensive that large flakes of concrete have become detached, exposing the steel. Wherever the steel has become visible it is seen to be coated with a layer of red rust, often as much as $\frac{1}{4}$ in. thick. The cracks appear on the under side of horizontal beams, and run vertically along the surfaces of columns.

The general effect is well seen in *Figs.* 1, 2, 3, 4 and 5, which are photographs of beams and columns in the New York packing warehouse. It will be seen how the cracking follows the reinforcement, *Fig.* 3 being particularly instructive as showing how the corrosion of a stirrup has resulted in forcing outwards and detaching a flake of concrete of considerable area. In all, 3,000 linear feet of beams and seven columns are affected in this building. *Fig.* 6 shows, on the other hand, that the reinforced floor panels are uninjured, a fact which must be attributed to the absence of an electrical connection between the reinforcing steel of the beams and that of the panels. The vertical crack in *Fig.* 5 is 4 in. deep.

The coal-barge jetty and quay at Southampton show chiefly cracks on the lower side of the deck beams, and, to a lesser extent, on the piles and diagonal struts above high-water level. In this case the conditions were somewhat complicated by the fact that the jetty had been undoubtedly somewhat severely strained by the racking stresses of heavy cranes working on it, and jarred by the bumping of vessels. The damage was, however, practically as great at the end of the jetty, where cranes never rest, as immediately beneath them. The concrete in each of the structures referred to proved to be of satisfactory quality, and although some of the stirrups in the jetty and quay were found to have

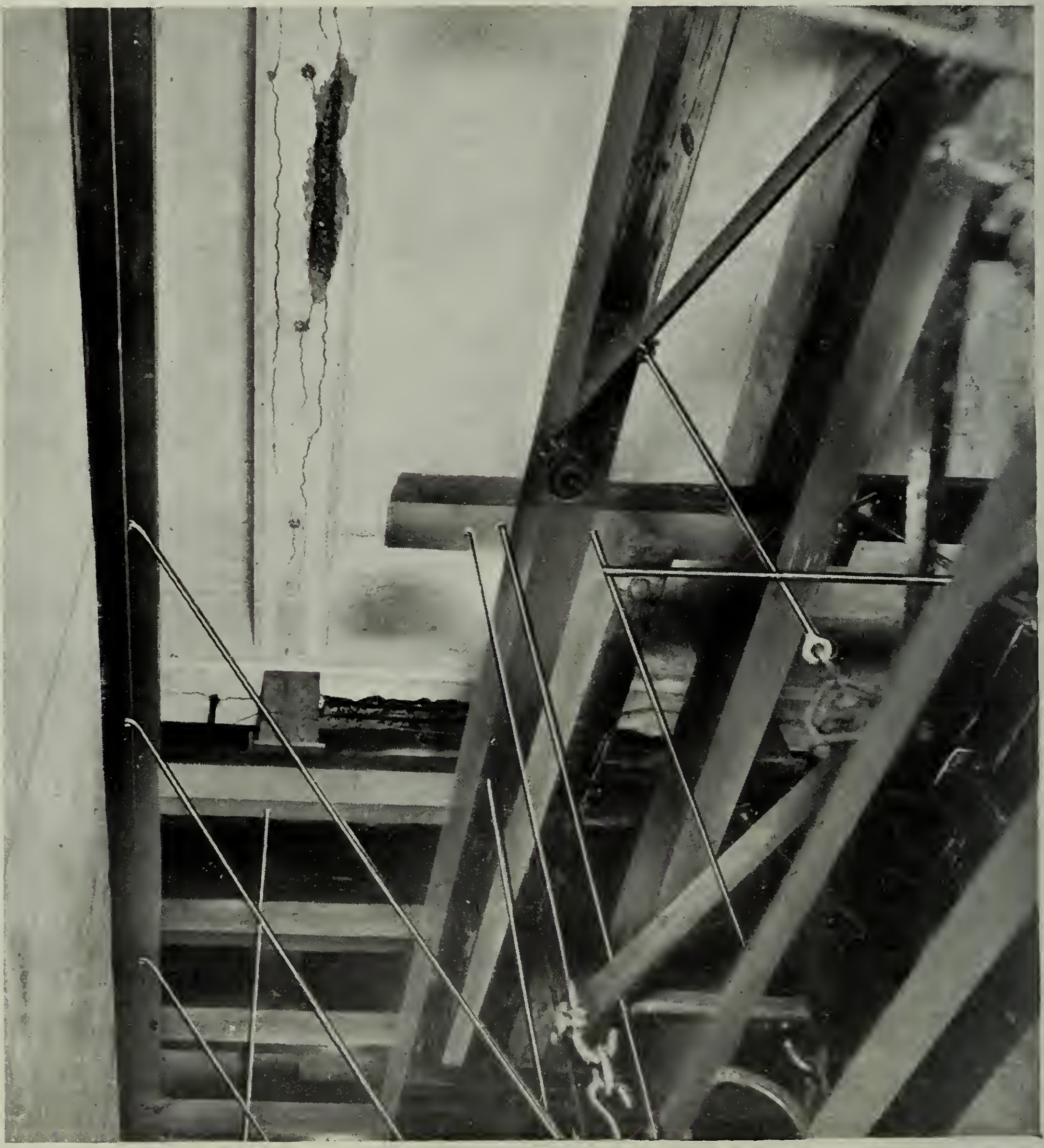


Fig. 2. Cracks in lower part of a girder.
THE ELECTROLYTIC CORROSION OF STEEL REINFORCEMENT.

been considerably displaced during construction, the committee did not regard this defect as important, or at any rate as contributing in any marked degree to the injury.

Electrical Conditions.—Suspicion, in the case of the New York building, fell at first on an electric railway, the lines of which run beside the building on two sides. Electrical measurements showed, however, that the drop of potential between a pipe which was, through a faulty connection, charged from the railway circuit and the reinforcement was only a few millivolts, and could not be held responsible for the corrosion. On the other hand, leakage from the lighting circuit was found to be very serious. In the neighbourhood of some of the most severe cracking, including the splitting of the concrete below the stirrups, shown in *Fig.* 3, a drop of potential of 10 volts to 20 volts was observed.

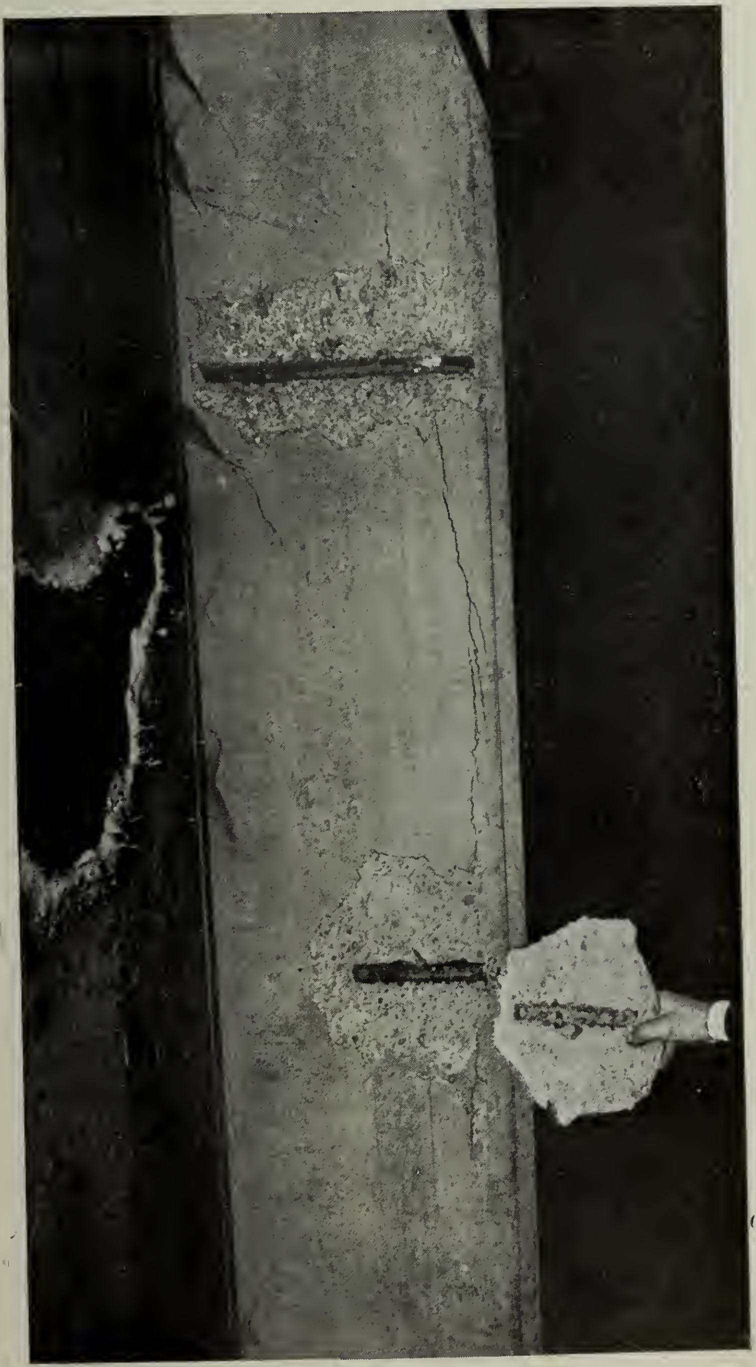


Fig. 3. Concrete forced off at stirrups of beam.

The Electrolytic Corrosion of Steel Reinforcement.

In order to carry the water and steam pipes and the overhead tramways used in the building, each beam or girder is provided with two or more cast-iron sockets, bolted to the reinforcing rods and reaching the lower surface of the concrete, as shown in *Fig.* 2. The electric leads are also carried by these iron sockets, the 120-volt rubber-covered leads being enclosed in japanned steel conduits, which have openings at each switch, outlet and fixture. As steam and acid vapours arise all over the building from the processes carried on, these vapours naturally condense in the conduits and cause leakage of current through the conduits, brackets and sockets to the steel reinforcement. The most serious injury is under rooms cooled by refrigerating pipes. Here the concrete is constantly moist, and therefore a conductor of electricity. We have, in consequence, a current passing from steel to steel through concrete more or less saturated with a solution of various salts; in other words, we have the necessary conditions for electrolytic action. Direct measurements with two voltmeters showed that the potential fall in the concrete was unaffected by switching off the railway current, and was therefore due only to the lighting circuit.

When the electrical conditions of the Southampton jetty were investigated, it was found that the return wire of the lighting circuit was earthed to a steel bridge resting on the jetty. The current could only find its way to the earth through a water main or through the reinforced concrete. A difference of potential of 9 volts or 10 volts existed between the steel of the bridge and the water. When the reinforcement was exposed and connected with the water, a difference of potential of only 0·04 volt was found between it and the water. This difference is very small, and probably does not represent the actual leakage.

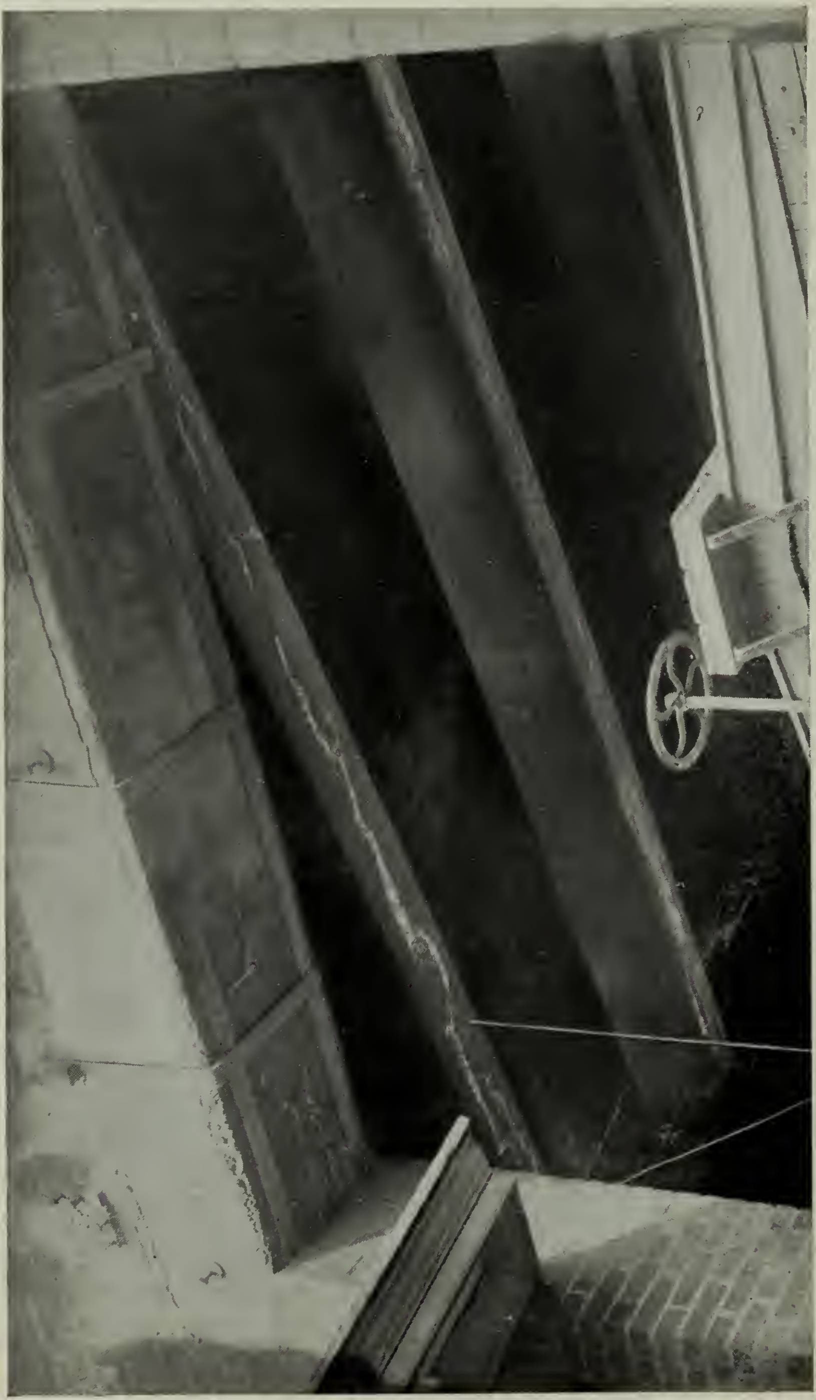


Fig. 4. Cracking on underside of beams.

The Electrolytic Corrosion of Steel Reinforcement.

On the Extension Quay at Southampton a difference of potential of 0·11 volt was found between the reinforcement and the water. As the tramway rails on the quay were about 0·30 volt higher, this was probably the source of the electrolytic action.

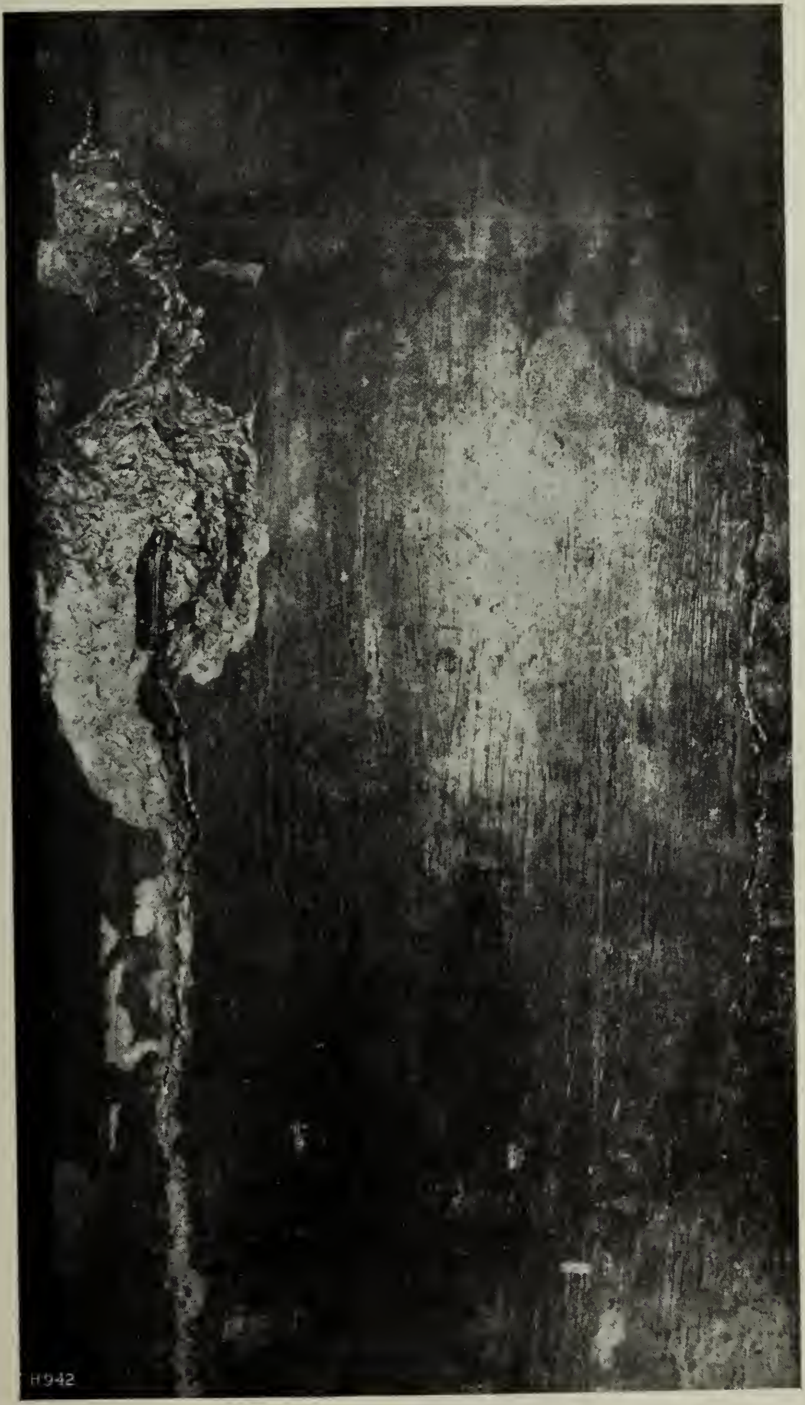


Fig. 5. Cracks in a column along reinforcement.
The Electrolytic Corrosion of Steel Reinforcement.

Experimental Tests. — Mr. H. P. Brown's investigations included some experiments with concrete blocks, 5 in. by $4\frac{1}{8}$ in. by $9\frac{1}{8}$ in., each containing two 1-in. steel rods. These were placed in circuit in the building at points at which leakage was found, and whilst those connected with the railway line remained uncracked, those which received the leakage from the lighting circuit cracked in the course of two days around the positive rod, and in nine days the crack was 2 in. deep.

Conductivity of Mortar.—Messrs. Magnusson and Smith found that the electrical resistance of dry neat cement blocks, after setting for twenty days in moist air and then being dried for forty days, was 1,270 megohms per cubic centimetre, and that of a 1 : 3 mortar under similar conditions 1,060 megohms ; that is, the material is an insulator. When moist, however, the resistance falls enormously, values of from 8,700 ohms. to 2,900 ohms. being obtained, the resistance depending on whether plain water or a salt solution is present The effect of moisture on neat cement and mortar is practically the same.

Passing a current through moist concrete blocks was not found to have any appreciable effect on the material. Other observers have found actual damage from this cause, but it is unlikely that the current densities arising from leakage will produce disintegration in the absence of steel reinforcement. Corrosion could be in a large measure checked by painting the reinforcing rods or otherwise protecting them, but it is obvious that this safeguard is insufficient, and that wherever the protective coating becomes defective damage may occur. Moreover, the loss of adhesion between concrete and reinforcement caused by painting the latter must not be overlooked. No protective measure of this kind will succeed in preventing corrosion for any lengthened period.

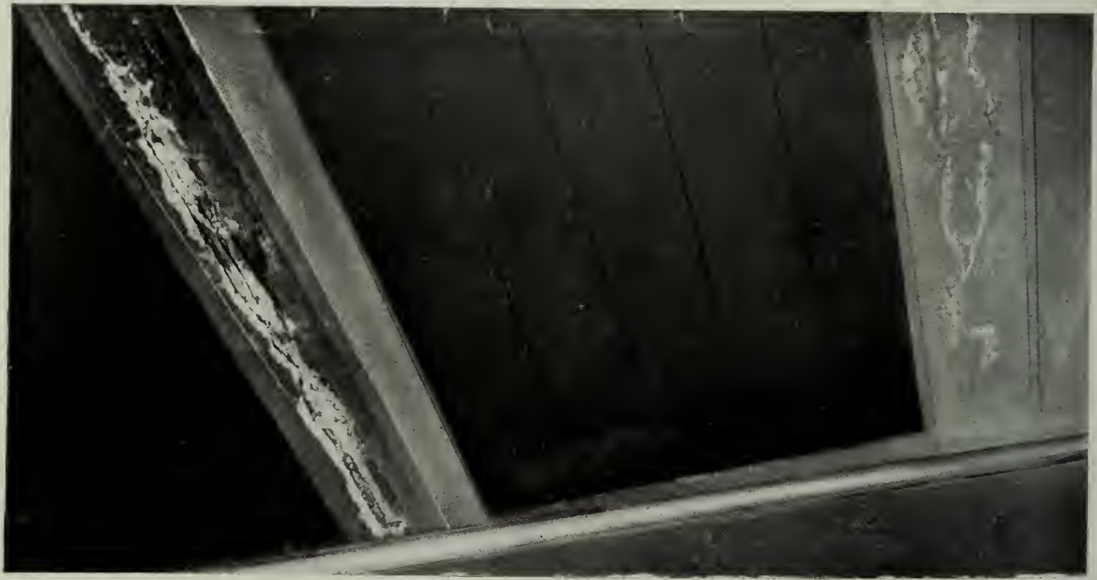


Fig. 6. Typical beams affected by the electrolytic action.
THE ELECTROLYTIC CORROSION OF STEEL REINFORCEMENT.

Experiments with Different Electrodes.—Previous experiments, using high current densities, had been made by Mr. U. J. Nicholas, of the Massachusetts Institute, Prof. A. S. Langsdorf, of St. Louis, and Messrs. Eltinge and Beers, of the Rensselaer Polytechnic Institute, but the effects observed were undoubtedly due very largely to expansion by heat. The more extensive experiments of Mr. Barker and Prof. Upson were directed towards the comparison of different electrodes, and of different current densities. The concrete used was a 1 : 2 : 4 mixture with sandstone aggregate, and the specimens were tested simultaneously to obtain comparative results. Both alternating and direct currents were used, so adjusted that 0·1 ampere passed in each case. With direct current and embedded iron electrodes cracking developed after about twenty days, whilst alternating current of such low density did not produce any effect. Heavy alternating currents of 3 amperes split the blocks after eight hours to ten hours, but the effect in this case was evidently due to the heating effect of the current, and not to electrolysis. Collapsible electrodes made of sheet iron rolled up in a spiral lasted longer, owing to room being allowed for the formation of oxide, but the final result was the same. Carbon electrodes, although no iron oxide was formed, caused expansion and disintegration, most likely on account of impurities in the carbon used.

Blank experiments showed that the rise of temperature due to the passage of the small current was insufficient of itself to do any damage, and the effect is therefore to be attributed to the formation of rust and consequent expansion. The rust appears partly at the anode surface, but also partly in the mass of the concrete. Some rather inconclusive measurements were also made of the strength of concrete blocks subjected to electrolysis. No noticeable reduction of strength was observed up to the point at which cracking took place. The general result of these experiments is, then, that an accidental large leakage of direct current may bring about destruction in a few hours, whilst gradual small leakage may cause cracking after an interval of weeks, months, or years. Alternating currents of such strength as are likely to be met with are without effect.

The Effect on Reinforced Concrete Structures.—After the discovery of the state to which the beams of the New York building had been reduced by electrolysis, it was decided to make loading tests on some of the most severely injured beams, in order to determine whether they had become unsafe. Two beams, 20 ft. to 21 ft. span, were selected for the test. They were 12 in. wide by 18½ in. deep below the slab, 5 ft. 3 in. from centre to centre. Loading up to 250 lb. per sq. ft. produced deflections in the centre of 0·033 in. and 0·05 in. respectively. The deflection increased regularly as the load was applied, and it was evident that the beams were still amply strong enough for their work. This is probably due to their originally having a strength in excess of requirements, in part also to the cracking being limited to the middle section of each beam. The original arrangement of the reinforcement was wasteful of steel and contrary to good practice, and were the electrolytic corrosion to proceed much farther there is no doubt that the adhesion between the steel and the concrete would be so thoroughly destroyed that complete failure would occur. The damage to the Southampton structures was less serious, but was of the same nature. Other reinforced concrete quay structures in the same neighbourhood, including Messrs. Thornycroft's jetty at Woolston, constructed as far back as 1899, were uninjured, and in these cases leakage of electric current was found to be absent.

Conclusions.—The following conclusions may be drawn from the published results, and are in the main identical with those drawn by Mr. H. P. Brown :

1. All electrical leads must be well insulated. Rubber-covered wires in japanned steel conduits are unsuited for the purpose, especially where steam and acid fumes are present in the atmosphere.
2. The intermediate wire should not be earthed in 3-wire systems.
3. The secondary circuit of a transformer should not be earthed within a building.
4. All the reinforcing steel in a structure should be in electrical connection by means of binding wire.
5. Gas, water and steam pipes should be insulated where they pass through concrete walls, etc.
6. In new buildings of steel or reinforced concrete the foundation steel should rest on good concrete.
7. Frequent tests should be made with a voltmeter to detect small stray currents, and whenever a pipe or reinforcing rod is found to be positive to the earth or to a neighbouring conductor steps should at once be taken to remedy the leak.

SOME METHODS OF CONSTRUCTION.

We have received particulars as to two new forms of construction which have recently been introduced on the English market, namely, the "Clinton" system of reinforcement and "Dentile" hollow floor construction. The details below should, of course, be read as ex parte statements of their promoters, but we commend them to our readers as extremely interesting methods of construction and worthy of attention.—ED.

THE "PARAGON" AND "CLINTON" SYSTEMS OF REINFORCEMENT.

THE "Paragon" stirrups, hoopings, and helical wrappings, made by the British Reinforced Concrete Engineering Co., Ltd., of Manchester, have been in use as rigid beam and column reinforcements for a number of years, and we have on more than one occasion given particulars of buildings in which they have been used. The company have now supplemented this method by a rigid slab reinforcement, known as "Clinton Fabric," consisting of a rectangular mesh made from high-tension steel wire of light and heavy gauges. It is claimed by the makers that the Paragon system of beam and column reinforcement, supplemented by the Clinton electrically cross-welded steel wire reinforcement for floors, slabs, roofs, etc., gives the most complete and rigid construction possible.

The Paragon stirrup, shown in *Fig.* 2, is so constructed that it can be moved intentionally with the greatest of ease, but cannot be displaced unintentionally through careless handling or ramming. This desirable feature is due to the fact that the force required to loosen and move the stirrup consists simply of squeezing the arms of the stirrup together, the manner of application and the direction of such force being opposite to any force likely to be applied through accident or carelessness.

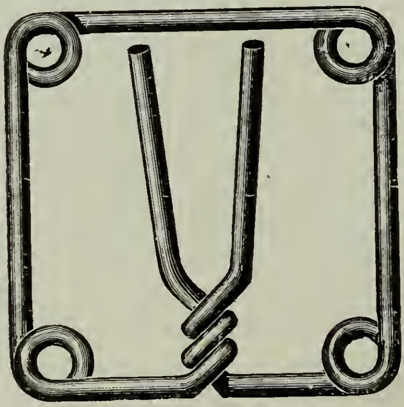


Fig. 1. Paragon Hooping.

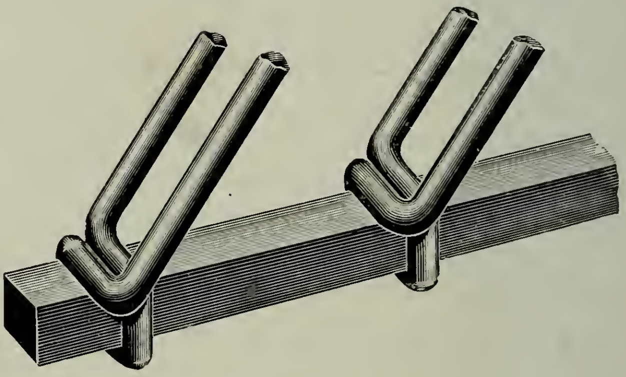


Fig. 2. Paragon Stirrups.

The stirrups, as will be seen in *Fig.* 3, are used with round or square bars, and can be fixed in any position with the greatest ease, thus combining simple application with rigidity when placed.

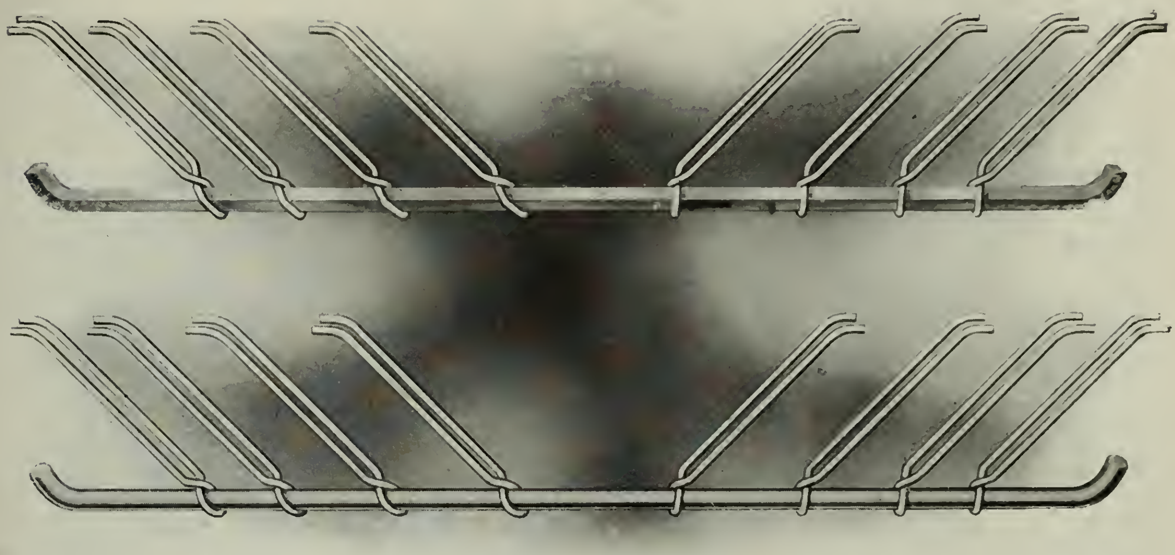


Fig. 3. Square and Round Bars with Paragon Stirrups.

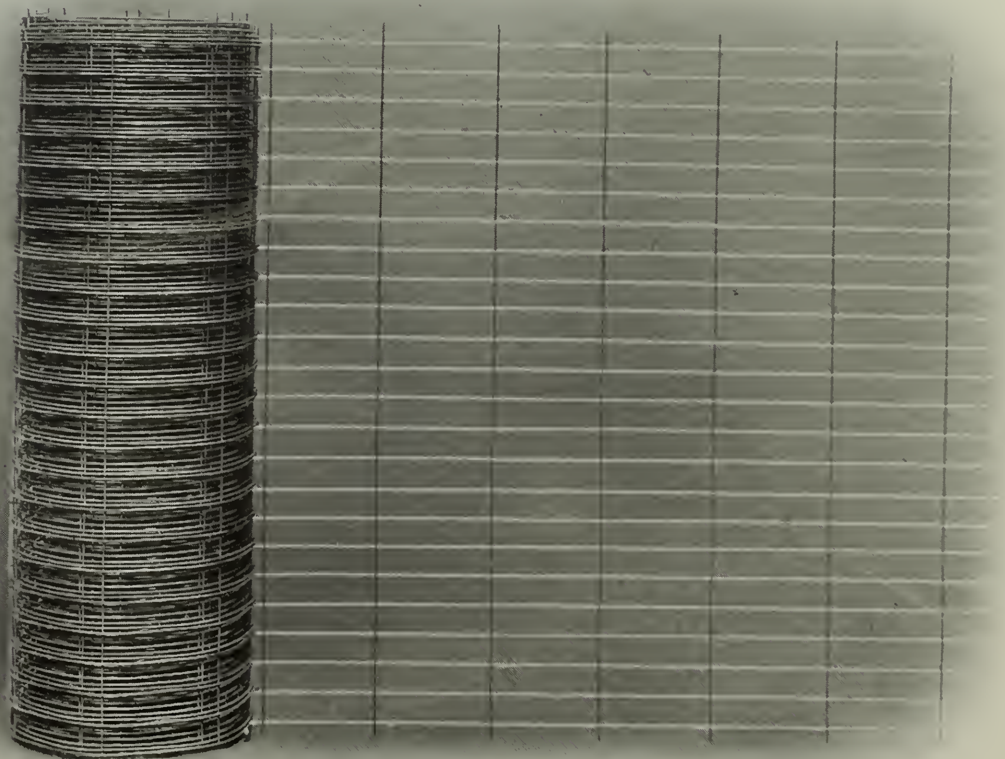


Fig. 4. A Roll of Clinton Fabric.

In addition to the tension bar which passes through the loop, a second tension bar can be placed just above the loop to lie between the arms of the stirrup and be prevented from moving sideways. This arrangement is generally adopted by the company. It allows the top bar to be bent up over supports as a contraflexure bar for continuous girders, while the lower bar runs straight on

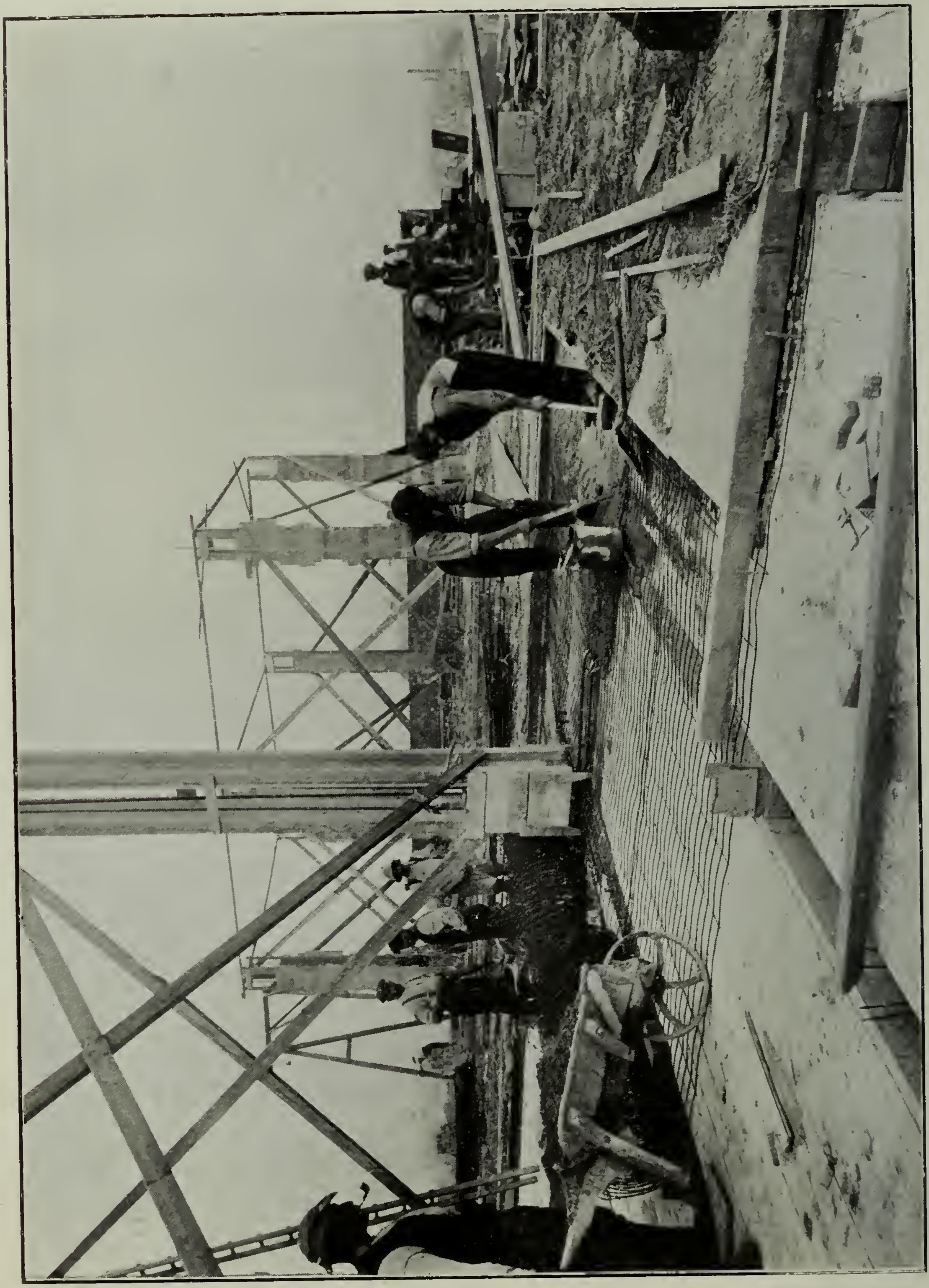


Fig 5. View showing Method of Laying Clinton Fabric.

The Paragon hooping, used in columns and illustrated in *Fig.* 1, is arranged with loops at the corners to grip the bars and prevent displacement. Experience has shown that without some such device it is almost impossible to prevent displacement, which, of course, may mean a serious weakening of the column. The arms, which form part and parcel of the hoopings, lie across the core of the column and reinforce it against shear.

The helical wrappings, also used for column reinforcement, in combination with looped hoopings to hold the bars in position, are made in short lengths, and are also provided with arms turned in to lie across the core. The helical wrappings, being used in short lengths, allow the concrete to be efficiently rammed in full view and under proper supervision.

The Clinton Fabric, manufactured in England by the British Reinforced Concrete Engineering Co., consists of a wire mesh made up of a series of parallel longitudinal wires, spaced at certain distances apart, and held at intervals by means of transverse wires arranged at right angles to the longitudinal ones, being securely welded to them at the points of intersection by a patented electrical process. An illustration of the mesh is shown in *Fig.* 4, from which the perfect alignment of the wires is plainly seen. The standard size of mesh varies from 3 in. by 12 in. to 3 in. by 18 in., but any required mesh can be made.

The British Reinforced Concrete Engineering Co. have sent us a copy of their new catalogue dealing with these two systems of reinforcement. It is extremely well got up, and is excellently illustrated. Besides giving particulars of the systems and photographs and plans of structures in which they have been used, the book contains a large amount of valuable information arranged in a very convenient manner. There is a series of tables for columns, rectangular, and T-beams, lintels, floor slabs, hollow floors, wall, and column foundations, and piles. The tables give full particulars of sizes and safe loads carefully selected to provide for all ordinary cases of loading. The external dimensions and the internal reinforcements of the various sections are seen at a glance, and other necessary information is clearly given. The sizes are all designed and calculated in accordance with the recommendations of the second report of the Joint Committee on Reinforced Concrete, the greater portion of which is reproduced in the book. There is a special article dealing with the mixing, shuttering, cost, etc., of concrete.

Altogether the company are to be congratulated on the production of the book; it is a most useful work, and should be on the desk of everyone interested in reinforced concrete work.

DENTILE HOLLOW FLOOR CONSTRUCTION.

THE Dentile hollow floor construction, which has been put on the English market by the Indented Bar and Concrete Engineering Co., Ltd., has been used with success throughout the United States for some years. Having regard to its interesting character, we are giving some details taken from particulars put at our disposal by the above-mentioned company. Their main argument in its favour is that this floor contains certain advantages claimed by the owners of tile floors (terra-cotta slabs) together with the well-known advantages of reinforced concrete construction. They hold that the best features of both forms have been adopted.

Dentile floors are constructed by placing upon the forms hollow tile blocks, which are so constructed as to be closed upon all six sides, and are provided with projecting flanges that serve to space them at proper intervals, leaving channels or ribs which are filled with concrete after the reinforcing bars are placed in position. In the majority of cases the floor is completed by a layer of concrete spread on top of the tile.

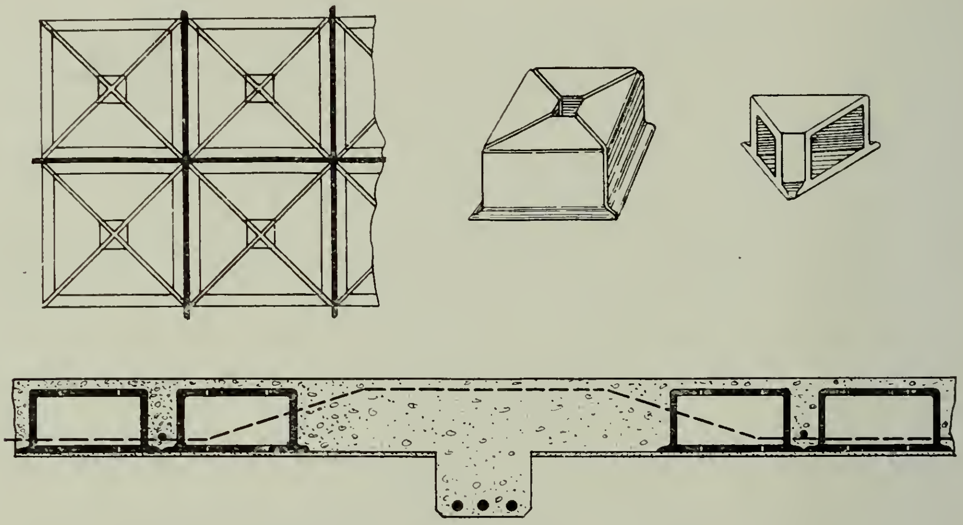


Fig. 6. The Mitre Tile.

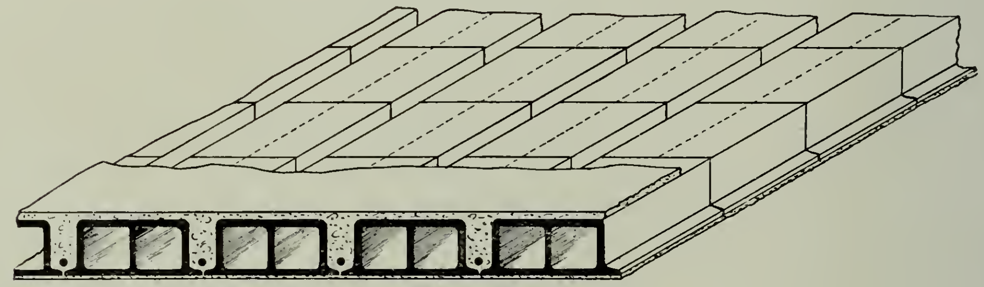


Fig. 7. The Bridge Tile.

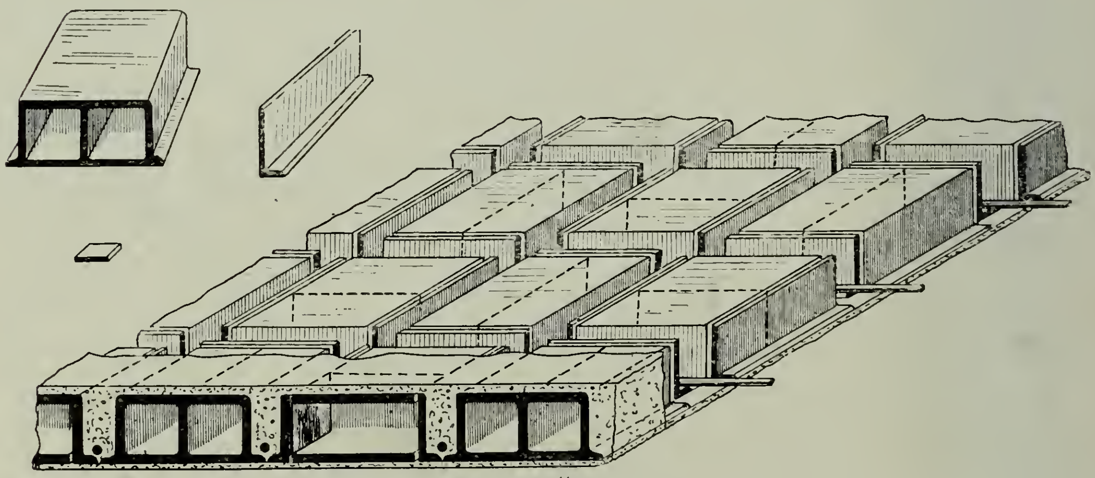


Fig. 8. The "L" Tile.

DENTILE HOLLOW FLOOR CONSTRUCTION.

The completed floor therefore consists of comparatively deep ribs of concrete, the spaces between being filled with hollow tile. The concrete structural members thus formed are protected at the bottom by a continuous surface of tile, while the tile blocks are guarded against mechanical injury by a layer of concrete.

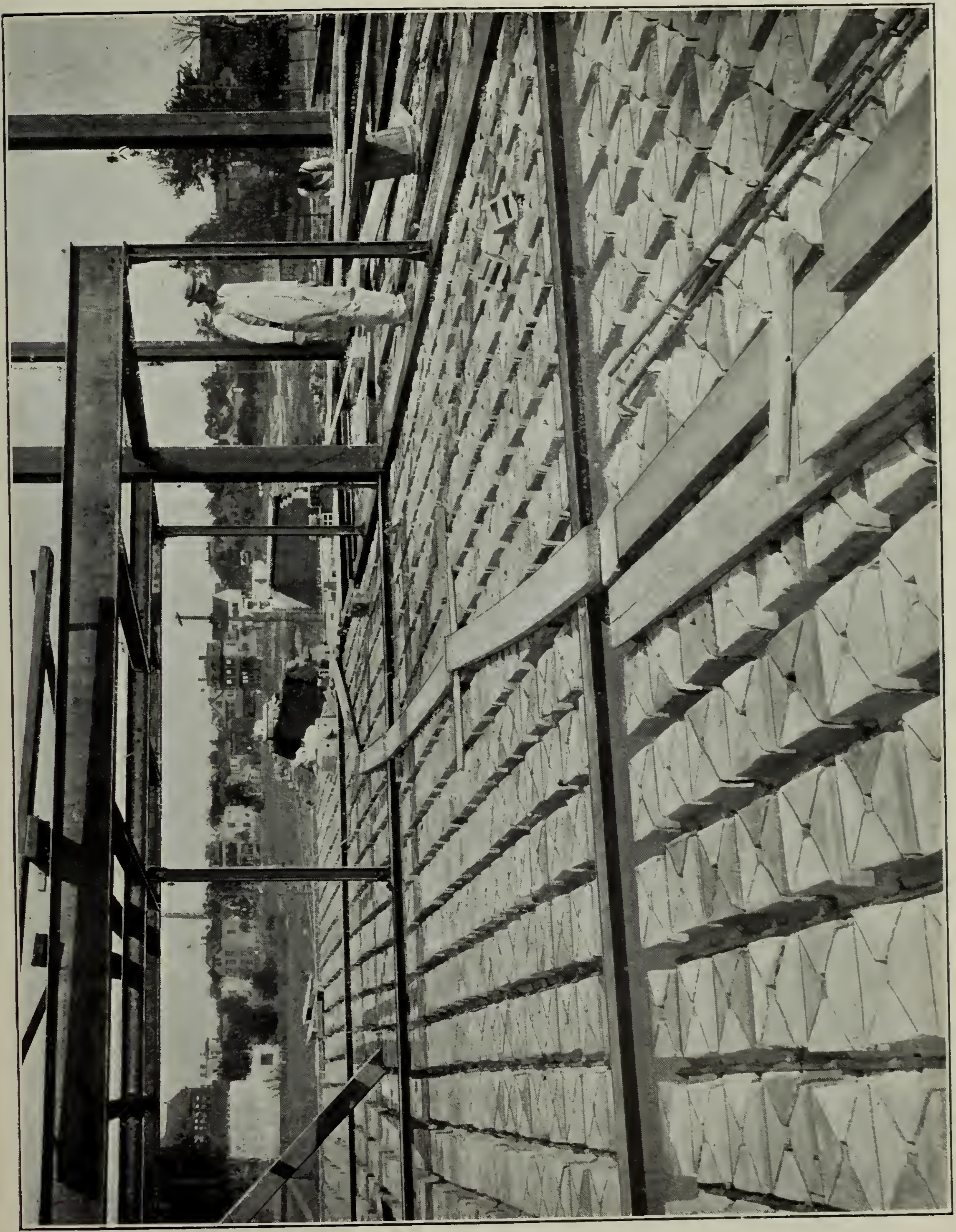


Fig. 9. The Mitre Tile in course of laying.
Dentile Hollow Floor Construction.

The construction of these floors is very simple and economical, and any contractor can carry out the work without previous experience.

Among the advantages claimed for this system of floor construction are lightness, rigidity, simplicity of construction, and economy. By this method less head-room is required than with systems reinforced in one direction only, as the whole depth of the secondary beams is saved.

Another advantage put forward is that as the tiles are automatically spaced at the proper distance apart by the projecting flanges, while the reinforcing bars are held rigidly in the proper positions in each rib, no mistake can be made in construction.

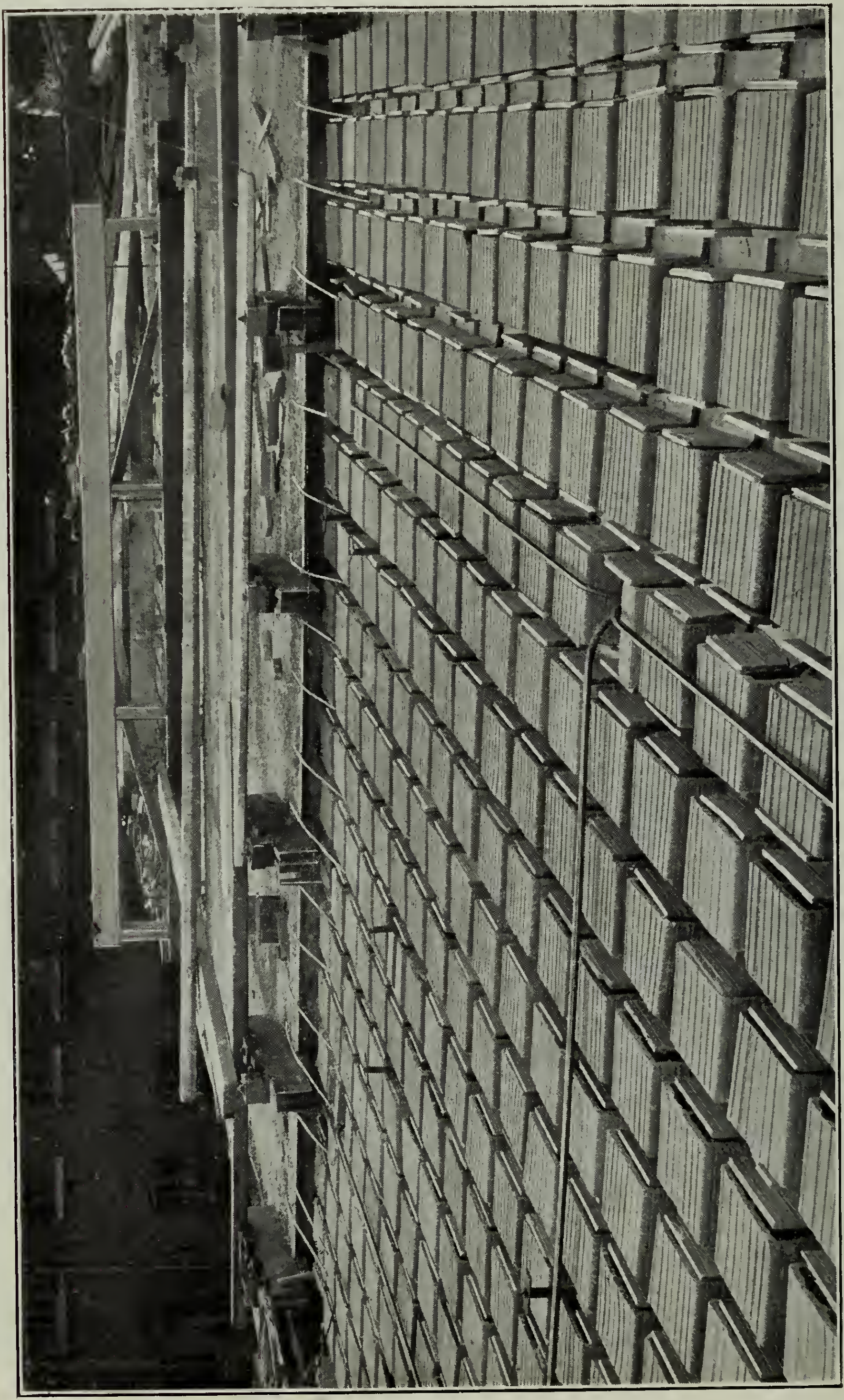


Fig. 10. View of Floor of "L" Tiles during construction.
DENTILE HOLLOW FLOOR CONSTRUCTION.

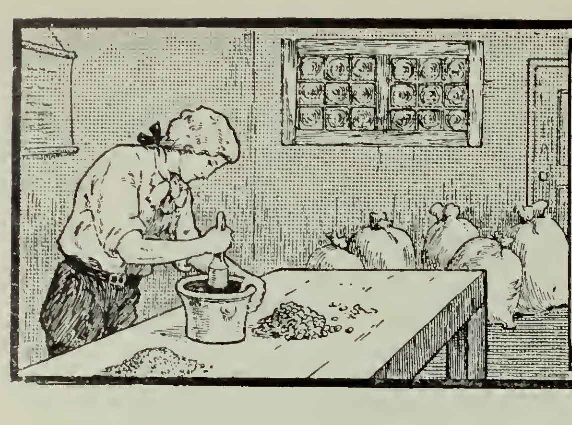
Extremely long spans can be used with the Dentile system, clear spans up to 32 ft. having been built and subjected to severe test, while spans up to 40 ft. can be used where the loads are light and the surrounding conditions favourable.

There are three types of these floors for various conditions of span, etc., viz.—Mitre tiles, Bridge tiles, "L" tiles.

Mitre Tiles.—These are for use with a two-way system of reinforcement. As shown in *Fig.* 6, each unit consists of four wedge-shaped portions, which fit accurately together so as to form a closed hollow block. This enables the reinforcement to be placed in both directions, and a very large span can therefore be obtained without beams. A feature of this tile is that the lip all round the tile forms the bottom of the concrete beam, so that the whole of the under surface of the floor is completely covered by the tiles, which are roughened to receive plaster, and no concrete is exposed. The illustration in *Fig.* 9 shows a Dentile floor in course of construction with Mitre tiles.

Bridge Tiles.—This tile is shown in *Fig.* 7. When used alone it is a perfect tile for small spans where a one-way system of reinforcement is desirable. Like the Mitre tile, it affords a complete tiled surface to receive plaster on the underneath side of the floor. The lip at the sides of the tiles ensures even spacing, and that there is no waste concrete or any weak places in the floor.

"L" Tiles.—These, in conjunction with Bridge tiles, can be used as a "two-way" system of reinforcement, as shown in *Fig.* 10. In the "L" floors small flat filling pieces are used to put in the square corners between the tiles, so that in this case also the whole of the underside is completely covered with roughened tile for plastering.



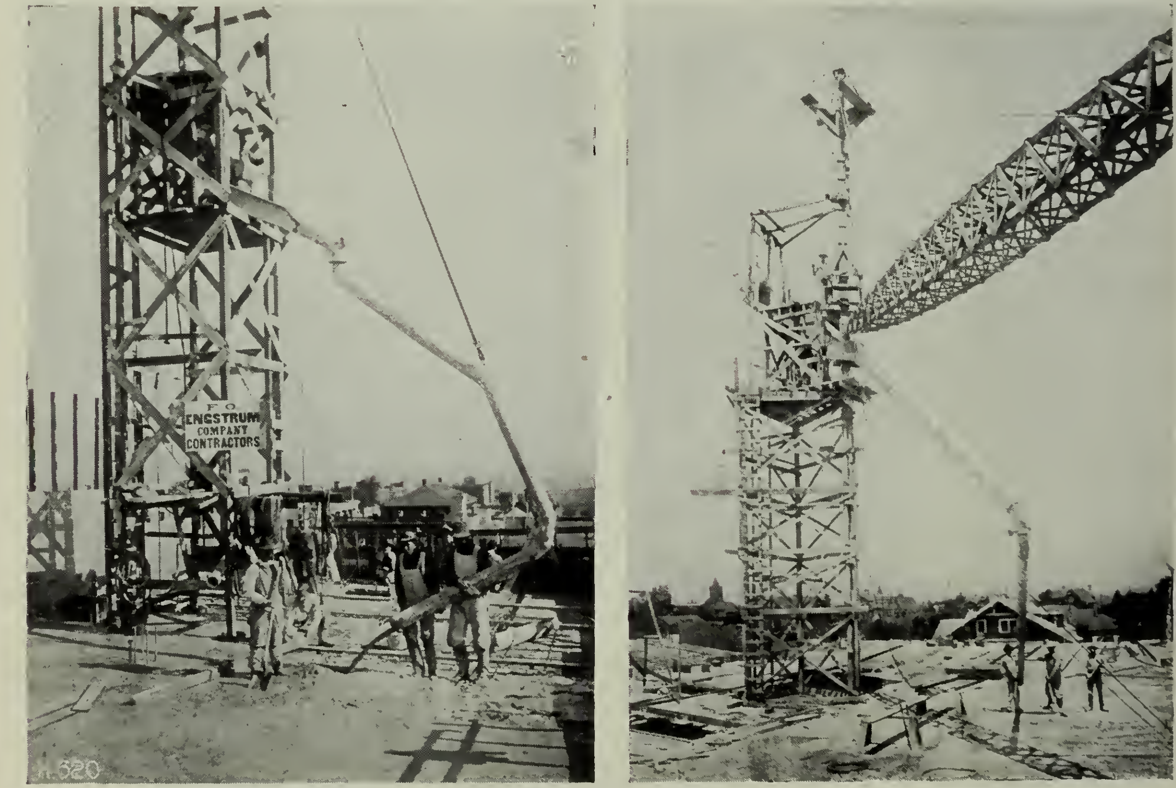
GRAVITY SYSTEM OF PLACING CONCRETE.

By EDWARD P. BAILEY.

The method of placing concrete described below is largely used in the United States, and should be of interest to those of our readers connected with the erection of large works in reinforced concrete.—ED.

THE gravity system of placing concrete described in this article is at the present time creating considerable attention, and a company has been formed to extend it to its fullest extent.

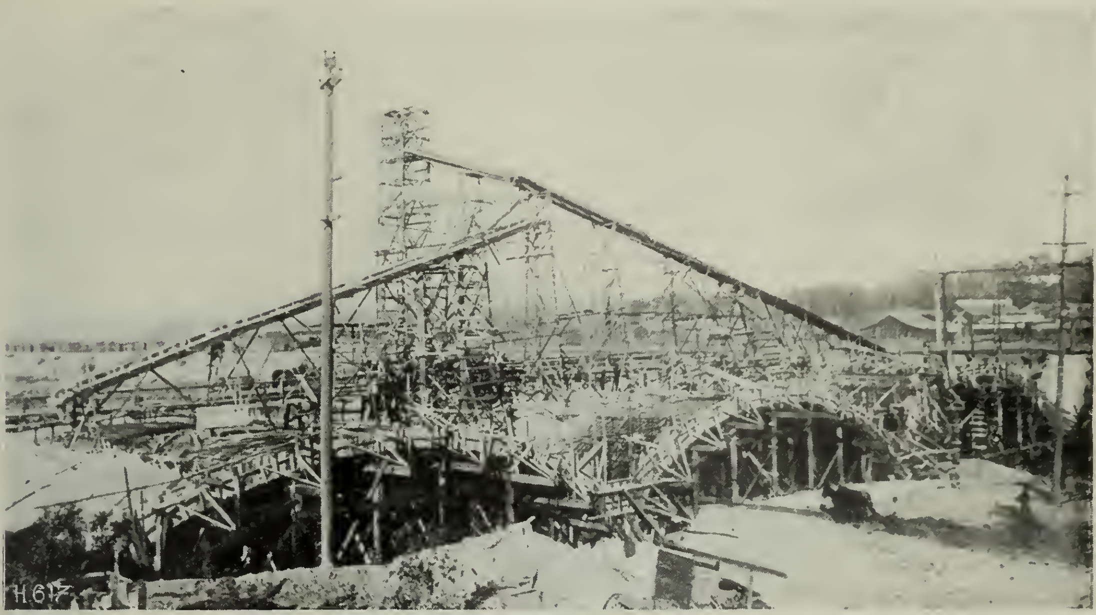
This system originated in Southern California, and it has been used in more or less practical manner in the erection of many of the largest buildings in the south-west of America, and in the construction of dams, bridges, and road and street beds where concrete was employed. From this vicinity, where the success of the system was amply demonstrated, its use spread up the Pacific Coast and eastward, for the great saving in the cost of the distributing and placing concrete instantly attracted



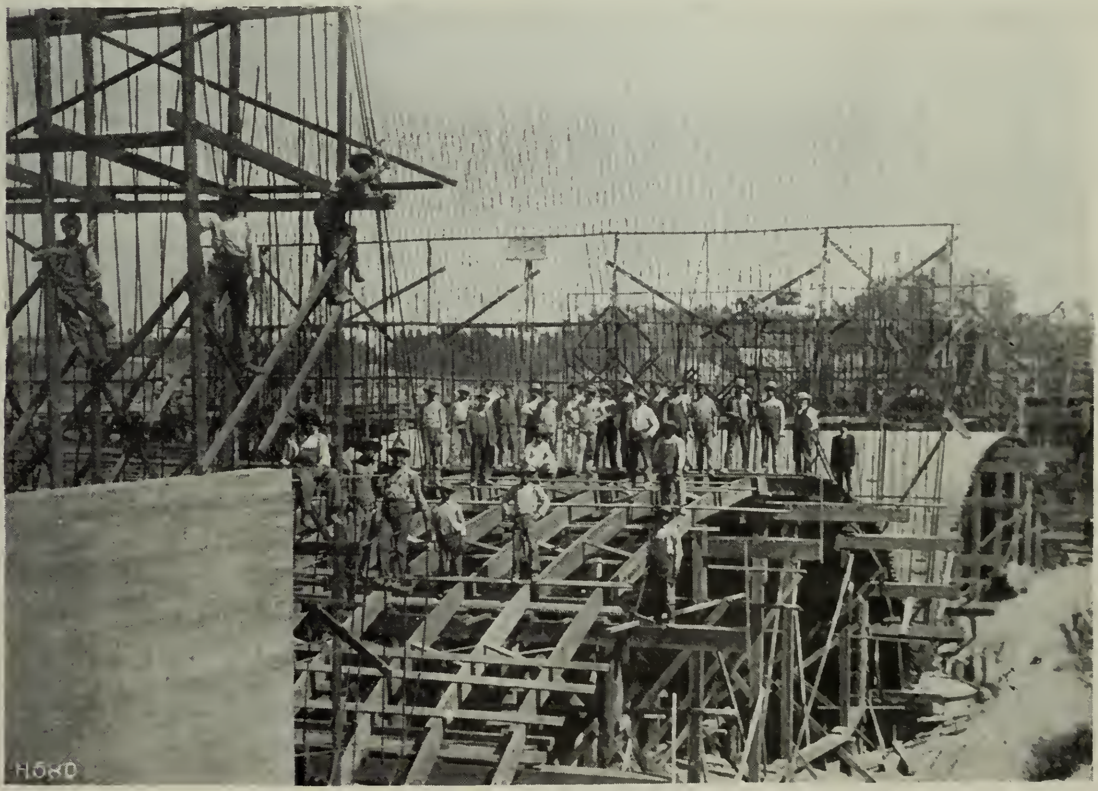
Placing Concrete for 8-storey Office Building, Los Angeles. Placing Concrete for Church in Pasadena, Cal.

GRAVITY SYSTEM OF PLACING CONCRETE.

attention from afar. The possibility of turning a large item of expense into profit, with the consequent advantage this would give the contractor in figuring a job of



Showing Central Tower over Mixing Plant Distributing through Open Flumes and Movable Auxiliary Chutes to Place.



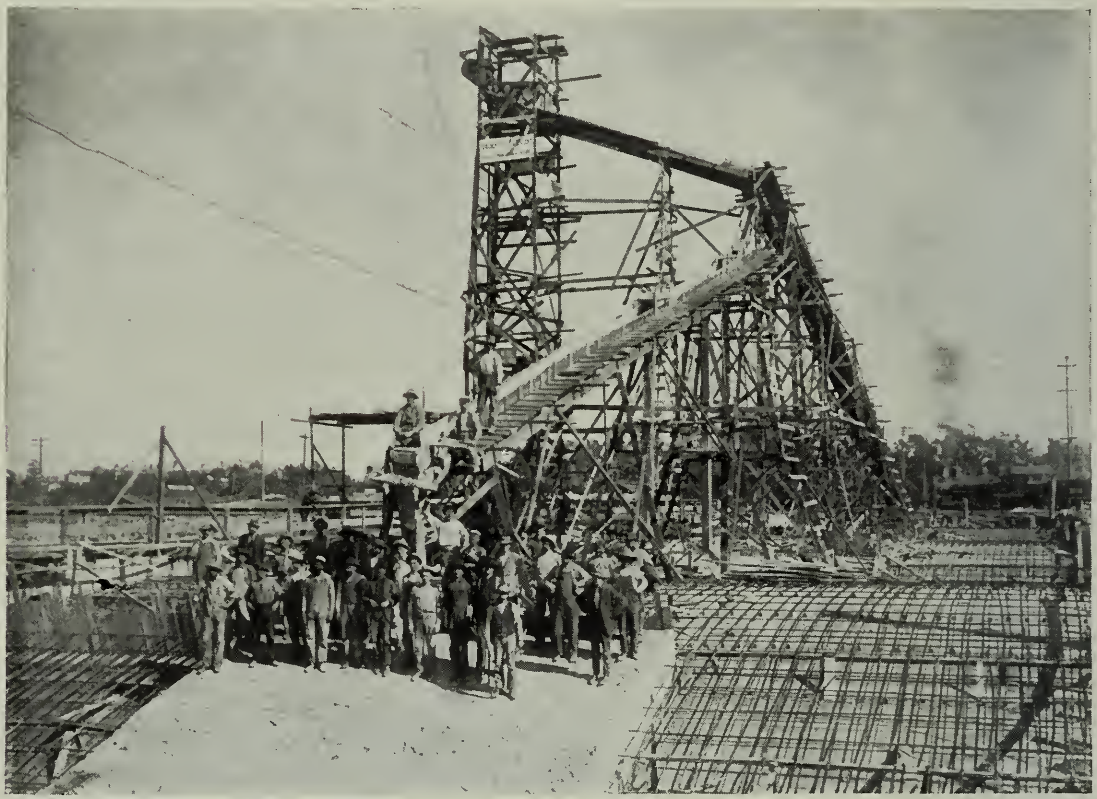
Showing Forms and Reinforcement.
THE CONSTRUCTION OF THE SEVENTH STREET BRIDGE, LOS ANGELES.

concrete construction, led to a quick adoption of the system by wide-awake builders far and near who learned of the new method and came to see it in operation.

The operations of this system are: (1) The mixing of the ingredients, stone, sand, and cement, in any suitable batch mixer ; (2) the hoisting by a skip of the mixed concrete or plastic material to an elevated hopper ; (3) the transferring of the concrete through pipes leading from this hopper to the point where it is desired to be placed ; (4) the extreme simplicity of design and construction.

A few of the points of the superiority of this method over the wheelbarrow or cart method of distributing are enumerated as follows :

First, the obtaining of the initial set of the concrete not *en route* from the mixer as is frequently the case in long hauls in cart or wheelbarrow, but in its proper place in the floor or wall, where the right condition of the concrete before set is necessary to secure best results from the material. This is accomplished by the perfected gravity system, because of the rapid handling and depositing of the material into the forms in the shortest possible time.



View showing Reinforcement in Place and Method of Pouring Concrete.
THE CONSTRUCTION OF THE SEVENTH STREET BRIDGE, LOS ANGELES.

Second, a uniform, homogeneous, plastic mixture in place, due to the large quantity which can be poured at one time. This is secured by certain details in the construction of the perfected gravity system appliances, as was shown in pouring the columns of the Pasadena Christian Scientist Church. Here an iron rod was easily sunk after the forms had been filled with new concrete, down the entire depth of over 25 ft., showing that the rock was held in proper suspension in the concrete, and that the aggregates had not become separated.

Third, the unlimited variation in design of buildings to which the gravity system is adapted, from the simple foundation and dam work to the most complicated dome, column, and frieze work, such as found on tall buildings and overhanging cornices. The system has been used successfully and economically on all classes of structures, from the eight-storey, 32-ft. front office building shown in one of the illustrations, to long bridges, such as in the construction of the Seventh Street Bridge illustrated on pages 857 and 858. In the almost quarter mile long Precooling plant at San Bernardino the concrete was run by gravity a distance of 502 ft.

Fourth, the use at all times of a standard equipment for the entire process of mixing, transferring, and placing, much of which equipment can be secured at minimum or little expense.

Fifth, in floor work the saving of breakage of hollow tile and displacement of steel, also in cost of labour and material in building runways. The cost of the tower for the gravity system is off-set by the cost of staging for barrow or cart runways, and the cost of pipe is more than off-set by the first cost and deterioration of wheelbarrows and carts.

Sixth, the assurance that deep, thin walls will be perfectly filled. This is claimed for the perfected gravity system by the improved construction of certain features in the appliances, heretofore noted, which guarantee proper condition of the concrete in place.

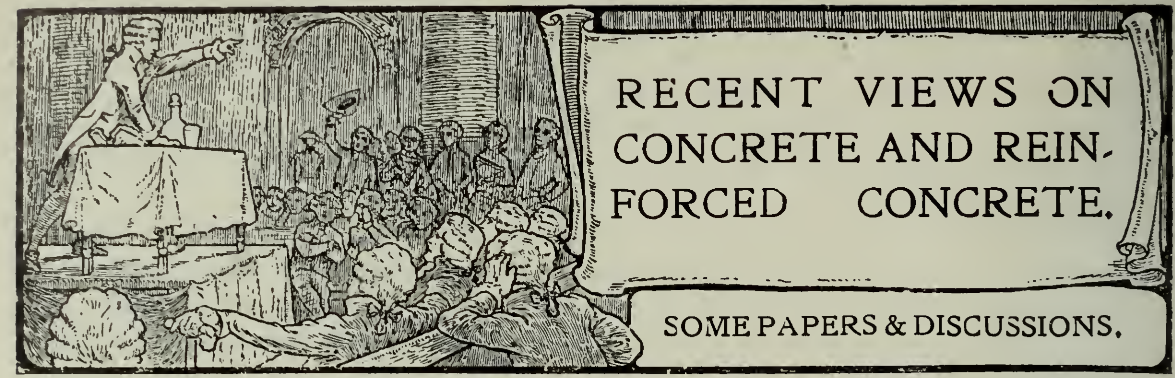
Seventh, the ability to handle large quantities quickly, the output being limited only by the mixing and hoisting capacity of the plant, thereby effecting a monolithic construction.

Cost.—Quality is always to be considered first. The gravity system, properly constructed and properly used, assures the quality. Next in importance is that of cost. In this respect this system is ahead of all others yet devised. Where by the wheelbarrow method of distributing the cost runs from 60 c. (2s. 6d.) to $1 (4s. 2d.) per yard, or by the use of carts from 40 c. (1s. 10d.) to 75 c. (3s. 10d.), by the employment of the gravity system this cost is reduced to 15 c. to 25 c.

This is the most apparent saving, yet there are many others of vital importance claimed, such as the shifting of planking or platforms and staging to delay work, displacement of tile, steel, etc. ; the putting up and taking down of scaffolding is uncertain as to cost, and very often a slow process. It is claimed that by the gravity system patching and replacing of concrete which sets prematurely is entirely avoided.

The construction world is displaying a lively interest in the newly-formed Concrete Appliances Co., organised to further a more extended use of concrete through the development of machinery and appliances for mixing, handling, and placing concrete and the exploitation of inventions along this line. This interest is due to the fact that the system of distributing and placing concrete herewith illustrated will be made of practical benefit to every contractor for concrete structures by the payment of a licence fee for its use, resulting in cutting down in one of the large items of expense in such construction. The licence fee has been figured down to a small percentage of the cost saving, and this fee will be required as a royalty for the use of the system.

The first appliances which this company controls through patent rights and is offering the building and construction world generally, is a perfected system of mixing, distributing, and placing concrete, using the " gravity system " described above.



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE CONCRETE INSTITUTE.

FIREPROOFING.

Paper by Mr. RICHARD L. HUMPHREY, of Philadelphia.

(President National Association of Cement Users.)

The Concrete Institute opened its Austumn Session on Thursday, October 26th last, at 8 p.m. with an ordinary general meeting at Denison House, Westminster, S.W., Sir Henry Tanner, C.B., F.R.I.B.A. (President of the Institute), presiding, when Mr. Richard L. Humphrey, of Philadelphia (President of the National Union of Cement Users), delivered an address on "Fireproofing," illustrated by some exceedingly interesting and instructive lantern slides.

MR. R. L. HUMPHREY, Reader of the Paper.

Generally.—It was rather an interesting proposition for an American to come to Europe and talk on the subject of fireproofing. The conditions in America were notoriously bad. America had the proud distinction of having the greatest fire losses in the world. The losses in America were enormous, and each succeeding year did not seem to bring an appreciable decrease in them. It would seem, therefore, rather incongruous for America to come and talk on the subject of fireproofing to a country that was particularly low in fire losses.

The very fact that they had such enormous losses in America had led them to study the subject of fireproofing and fire prevention, and it had been a necessity to find out ways and means to prevent the enormous annual destruction of building materials by fire.

In Europe, where the losses were low, the question was not by any means so urgent, and perhaps the same attention was not given to it as in America. Nevertheless his observation of the conditions in America and Europe led unquestionably to the conclusion that it behoved not only England, but all the countries of Europe, to study this question of fireproofing, and to study it seriously. In Europe there was a growing tendency to the concentration of enormous stacks of merchandise in buildings, and this was as much a menace in Europe as perhaps it was in America.

In this country they were blessed with an abundance of slate and building stone. In America they had an abundant supply of lumber, and the early settlers built frame structures; then structures of a permanent form began to be erected. These permanent buildings, however, were surrounded by the inflammable structures, which in time of conflagration served as a means for burning the more permanent structures; and throughout America there were numerous illustrations of small towns wiped out in the matter of a day, or perhaps a few hours, by reason of these frame structures.

The question of the construction of buildings was always a question of economy. Fortunately in America the increasing scarcity of lumber and the increasing cheapness of concrete had led in a large measure to the elimination of these flimsy buildings, so in time probably the menace that they had in so many of their cities would be eliminated.

No building was absolutely fireproof. In America the term "fireproof building" was used, but it was a dangerous appellation to put on a building. In the first place, it instilled in the minds of the occupants a sense of security that often led them to neglect those precautions which were so necessary and which, if the building were labelled "non-fireproof," they would be careful to observe. In America, under the rather poor building laws that were promulgated generally, they erected buildings of a low fire resistance, and equipped their fire departments with magnificent fire-fighting appliances, high-pressure water systems, and the country was subjected to a great annual tax for the maintenance of this expensive fire-fighting system.

The annual losses were not by any means represented by the annual destruction of property. In addition to the destruction of property and building materials, there was the annual tax necessary for the upkeep of the fire-protection service, and then the additional tax arising from the very high rates of insurance; so that, year by year, the total annual losses from fire, which he believed were entirely preventable, were represented by a great deal more than the two or three dollars per head, which was merely the value of the property destroyed.

It was regrettable that property that was once destroyed was a permanent destruction, and they felt in America, where the question of the concentration of the resources was receiving so much careful attention, that it was of the utmost importance that they should study the conservation of building materials, so that now generally throughout America there was a tendency to revise the building laws for the purpose of ensuring the erection of better structures. Of course, it was impossible to make those laws in a large measure retroactive, and there must necessarily exist for many years to come buildings which at best could only be described as tinder boxes.

It frequently happened that the walls of a structure were standing after a fire, and people pointed to those walls as an evidence of the fact that the building had satisfactorily passed the conflagration. Sometimes the walls were of concrete, and after the fire were in good shape, and only required a renewal of the floors, doors windows and roof, to make a habitable dwelling. People looked at that building with its walls of concrete and said, "Why, it is a first-class fireproof material." The value of the structure that remained was about 8 per cent. of the cost of the building; the other 92 per cent. had been destroyed. It was not the fault of the concrete. The doors were all wood, the roof was of wood, the windows and doors were all wood, so that was far from being a fireproof building.

Then again, it frequently happened that the floors and columns are fireproof, but the front walls are cast iron which are destroyed, or the walls of brick which fall down. He would show them one of the best examples in America of the behaviour of reinforced concrete in a serious conflagration. This was the building of the Guarantors Trust Company, of Baltimore, and load tests were made on the floors after the fire by the building department, and they were found to be amply safe under the ordinary building laws.

Fire Resistance of Stone.— Stone was very largely used not only in this country and in America, but all over the world, as an ornamental material, and it was evident, from the study of buildings where there have been fires of intense heat that the stone was almost entirely destroyed. It was almost impossible to replace the ornamental character without entirely rebuilding the structure. The behaviour of granite and hard sand stone in fire, which splintered and split, was ample evidence that the subject of natural building stones should be studied with a view to determining their resistance to fire. The United States Government had undertaken some studies of this kind, and they found that it made a material difference as to how the stone was quarried in its fire resistance. They found that granite could be quarried so as to offer almost 100 per cent greater resistance to fire in one direction than it did in the other direction; so that in the matter of ornamental building stones there was much to be learned in the manner in which the stone was quarried from the point of view of its fire resistance. If stone was to be used as a structural member of a building it must be fireproof, just the same as a steel member should be fireproof.

Protection of Steel.— In nearly all the great conflagrations which he had visited it was a frequent sight to see buildings of steel which had not been properly fireproofed, and it was evident that something must be done to protect that material, for while steel might have great strength at normal temperatures it had little or no strength at high temperatures. Then, again, it frequently happened that the floor of a structure might be reasonably fireproof and constructed properly, but the supports of the floor were cast iron, or some equally bad material, and the failure of the column to support the floor caused a collapse.

In the Academy of Science in San Francisco the architect made a slight mistake in the calculation of the size of the cast-iron column, and the contractor, in order to relieve the situation, filled the interior with concrete. When the conflagration occurred in San Francisco, the cast iron expanded under the action of heat, and cracked and feli, but the load above was carried by the concrete core, which was more fireproof.

Terra-Cotta.—It was a striking matter of fact that architects and people in general in America regard burnt clay as an admirable fire-proofing material. He thought in a large measure this opinion had been based on the fact that small pieces of burnt fire clay, when placed in a fire and got hot and thrown into water, are not disintegrated. But the clay was not used in that way, but in the shape of a tile. In the process of manufacture it often happened that these tiles were cracked in the corners, and when a column which was fireproofed was subjected to the action of heat, the unequal expansion of the outer face of the tile, as contrasted with the inner face against the steel, caused an expansion which the thin web at the corner was unable to resist, and the tile and the web cracked. As a result, the tile was broken away from the column, and the column, left to the action of the heat, collapsed.

He would show an illustration of this form of fireproofing with clay which he had previously described, where the space between columns has been protected by a thin veneer of perhaps two or three inches of terra-cotta. They could see where the column had settled eight or ten inches by buckling, and the floor above of concrete has been so seriously cracked as to endanger its safety.

Now, it frequently happened that where terra-cotta tiles had been used the lower web, by reason of its expansion, had flaked off. In a case of that kind nothing could be done in the way of restoration except by entire reconstruction of the floor.

Other Methods of "Fireproofing."—It often happened that in the construction of columns an attempt had been made to fireproof them by binding around the column perhaps a metal fabric, and then plastering it. In the Fairmont Hotel fire about 100 columns fell as a result of this kind of fireproofing. It frequently happened that the floor settled as much as a foot. Now there was no great fire in that building; the hotel had not been completed, and the only material there was lumber that was used in the construction of the building, which was not a great amount, but the burning of this lumber was sufficient to develop enough heat to buckle the flimsily constructed columns, and in the destruction of such buildings one frequently saw the folly of those flimsy evasions of the law.

A quite common type of fireproofing of a column in America consisted of perhaps one thickness of a wire mesh, with perhaps three-quarters of an inch of ordinary hard plaster. In the inside are placed pipes and other metal structures. The destruction of that fireproofing was very rapid. He had seen structures that had been fireproofed in that way, and one could not tell that they had failed except for a slight bulging in the wall, but when one came to tear away the fireproofing it was found that the column had buckled. Now, in a fire of any intensity, the first action on this plaster was to drive off the moisture, and leave an inner powder which is a good conductor of heat, and the conduction of heat to the steel causes the expansion and consequent buckling under the superimposed load.

In most of the newer building laws of America there were strict clauses which prohibited the embedding of pipes and conduits of various kinds in the fireproofing. He would show them the manner in which the contractor often worked in order to get the pipe in comfortably. Many of them were not discovered until a fire caused the stripping of the fireproofing, and then it was seen in one case how the contractor had broken away the web of a tile in order that the tile might be fitted around the pipes. Another difficulty in this form of construction was that it was impossible to get perfect tiles. They not only crack in the process of burning at the corners where the web joins, but in handling it frequently happened that they were broken and spoiled.

In the San Francisco and Baltimore fires this was a frequent sight—columns buckled and the floors settled anywhere from 12 in. to 18 in., and after the fire it became a problem as to what should be done. In some buildings jacks were employed, and these reinforced concrete floors were raised to their normal position, the buckled columns cut out, new ones put in and fireproofed, and they were passed by the authorities as being perfectly good. Just what the condition of the floor was after having settled 18 inches, and then being pushed back in position, no one knew.

The floor, of course, was an important structure. If the column was reasonably fireproof, it was necessary that the floor should be fireproof too. The suspended ceiling was a good idea, but, unfortunately, was not always properly carried out. It was found in the San Francisco and Baltimore fires that that ceiling, suspended on to the main ceiling, acted as an excellent shield and greatly increased the fire resistance of the floor. Unfortunately, in carrying out this idea, it frequently happened that ordinary gypsum or plaster was used, and with a very flimsy anchor the gypsum lost its life at a very low temperature, and the anchor was destroyed in heat and the ceiling fell.

He saw a building of reinforced concrete with columns well protected, but the engineer who designed the structure put a flat band of steel under the rib of concrete without any protection to the steel. It happened in this particular building, which was a warehouse, that there were great quantities of wooden boxes stored there. The heat expanded these bands, and the superimposed load all went through. Another evidence of lack of intelligence in designing the structure!

Another very common type of construction was where tiles were placed against the side of the girder, and a very thin coating of hard plaster placed over the tile and round the flanges. Of course, as far as the interior decoration of the building was concerned, this was economical and effective. As far as the fireproofing of the steel was concerned, it was absolutely of little value. It would be better if the steel girders were entirely unprotected, because then the people who occupied the building would realise that they were unprotected, and would exercise precaution to avoid a fire in that particular building. It frequently happened that the girders were protected with a thin protection of plaster supported on an anchor, and the failure of this plaster exposed the steel work to heat and caused the consequent destruction of the floor.

It generally happened that the roof trusses of a building were never protected. The upper ceiling was rendered reasonably fireproof, but the steel trusses of the roof were not protected, and as a result it frequently happened that the roof became the entry for a fire from the outside. It was just as necessary to protect the steel work of the roof as it was any other part of a structure.

Another common method of fireproofing was where the beam that carried the floor was simply protected with a very thin coating of plaster, and this ceiling was supported by a very light metal clip. By the action of the fire, although only of moderate intensity, the value of the plaster was quickly destroyed and the anchor failed, and the result was another ceiling was destroyed and came down, leaving the steel entirely to the mercy of the flames.

In most cities there were buildings of large size that are reasonably fireproof. They were monumental in their construction but were surrounded by fire traps, and this was particularly true in their large cities in America, where there were buildings extremely high, and which if they were properly protected with metallic window frames and door frames and fire-glass windows would probably act as a barrier, but with unprotected plain glass and perhaps wooden frames, the destruction of the tinder boxes surrounding them brought about the destruction of the contents of the buildings and often the buildings themselves.

It was not only necessary that the floors and columns of a building should be properly protected against fire; it was also necessary that the exterior exposures—not only the interior but the outside—should be protected. It frequently happened that the windows were perhaps metal frames protected with terra cotta or some similar fireproofing, and the destruction of these windows led to an easy access for the flames to spread from floor to floor, and resulted in the entire destruction of the building.

General Question of Fireproofing.—There was a tendency to-day for the development of great businesses, and with that came enormous warehouses. There was also a tendency, even where the laws of the country tended to restrict unbroken floor areas, to concentrate in buildings inflammable merchandise in large quantity. Now, in Europe an effort was made to build fireproof buildings, and then have a sufficient fire service to go quickly to a fire, so as to arrive there almost as soon as the fire occurred and extinguish it, and that, to his mind, was the ideal condition.

They should try to build reasonably fire-resisting buildings, and then provide such means as would prevent a fire in the contents. It was not sufficient argument for the fire resistance of a material to say that, because the skeleton of a building stood, the building was fireproof, because it frequently happened that the value of the structure as it stood was only perhaps 15 per cent. of the cost of the building.

He believed personally that concrete was going to play a very important *rôle* in the question of fireproof construction of the future, and the Concrete Institute of England and the concrete organisations of America had a very important responsibility and a very important task before them. It was known that concrete was reasonably fireproof, but not much was known about its properties or the methods of construction from the point of developing buildings of the highest fire resistance. In a report on the various concrete buildings that had been erected in America during the last five years, the owners of 23 per cent. of the buildings reported that they carried no insurance on the buildings themselves, and merely insured the contents.

It was just as necessary to provide fire protection for the concrete member in a structure as for a steel member, a wooden member, or a stone member. There was no doubt that different aggregates had different rates of expansion, and that these different rates of expansion caused a proportionate destruction of the concrete.

It behoved the members of concrete organisations not to stand on the superior excellence of concrete as a fireproofing material, but to study the question of its fire-resisting properties and the methods of its construction, so that they could intelligently design structures in which the material was applied to the very best advantage, because if conflagrations occurred in buildings that were not properly constructed, and they were destroyed, it reacted against the merit of the material; and it behoved the members interested in this industry to study this problem, and advance its intelligent use. It was not wise to say that concrete was fire-resisting and needed no protection. The structural members of a concrete building needed just as much protection as steel. He believed that, as years went round, there would be no reason why there should be even a loss of 33 per cent. per capita in the buildings of Europe.

The destruction of building materials by fire was preventable, and the fact that in America the loss was ten times greater than in Europe was no excuse why this country, with its years of experience and favourable conditions, should not exercise the same care to prevent the loss of 33 cents per head of its property every year as America was to prevent the loss of three dollars per head by the study of those problems, so that the whole world might be benefited.

He could not talk on the subject of fireproofing without paying his tribute to the admirable work which had been done in England, especially by the British Fire Prevention Committee. The effect of the work of that Committee, which was a work of love, had been felt especially in America and all over the world, and he was very glad to be able to testify to its merit and express his appreciation and thanks for the admirable work that this Committee was doing. It needed support and co-operation, and he believed that in an Institute of this character the study of the construction of buildings that were fireproof was something that should occupy their entire time.

In America they were erecting buildings of concrete, not from philanthropy, but because the buildings were in themselves economical. In the first place they could construct buildings of reinforced concrete in many cases more cheaply than they could be built of slow-burning wood. In the second place, the Insurance Companies placed a lower rate of insurance on such a building than they did on the other; and, in the third place, the maintenance of that building was considerably less than in the case of wood or steel, so that the owner of such a building was not actuated by philanthropy, or to help the cause, but was governed by dollar and cent propositions, and that was why so many buildings were being erected with reinforced concrete to-day, and it was a blessing to the country that such was the condition.

Unfortunately, the knowledge of the use of concrete was not definite, and there were many buildings erected which, in his judgment, were very flimsy, and some day they must have occasion to regret their erection, and it was all the more important that they should study the subject, frankly admit the weaknesses of concrete, and try to educate people into its proper use.

In this talk he hoped he had given them matters of interest and thought. It was a subject that he was particularly interested in, and he hoped to see the Concrete

Institute join in the study of the fire-resistance of concrete, because that was one of the most important phases of the study that needed attention at the present time. He had a warm regard and admiration for the work the Concrete Institute were doing, and he brought them the friendly co-operation and greeting of their American Association. It might be their good fortune to greet the members of the Institute in America, and he trusted there would always be between the two Institutes friendly co-operation in the advancement of the use of this material.

DISCUSSION.

Mr. Edwin O. Sachs, F.R.S.Ed. (Vice-President, Concrete Institute), in proposing a vote of thanks, said the members of the Concrete Institute were extremely indebted to Mr. Humphrey for devoting one of the few evenings he was spending in London at the present moment to be with them and to give them such a highly interesting "talk." They were also extremely indebted to him for bringing over such interesting slides, for the selection presented was eminently interesting and instructive. They could not have been better thought out and brought together.

Mr. Humphrey had mentioned the misnomer, "Fireproof." The word fireproof had certainly been a most abominable misnomer, and to his mind it had done more to injure the progress of true fire prevention than anything else. It was a bugbear to that famous fireman Sir Eyre Massey Shaw as far back as 1870, when he wrote scathingly about it in the public Press, and whatever had been done since to mitigate the use of that horrible word it was yet all too common, although its fashion was fortunately decreasing in certain degrees. In the United States there had also been much talk about the use of that particular word, "Fireproof," and he hoped there would be substituted for it some day the more suitable word, "Fire-resisting," which was the word that was gradually finding adoption in the British Empire.

The story illustrated in the lantern slides went very much to show that the use of hard terra-cotta slabs or "tiles" was not to be recommended in fire-resisting construction; in fact, terra-cotta, whether it be tile or semi-porous terra-cotta, as now often found on the market, was certainly out of place where true fire resistance was wanted. Nevertheless, they must always recollect that the employment of terra-cotta porous solid slabs and bricks could be safely used for light partition work and the like where only temporary protection was to be afforded in dwelling-houses or other domestic structures.

This matter of discriminating between different degrees of fire resistance made him suggest they should adopt more universally a classification between the different fire resistants. They should require for a "fully protected" building far more than in one intended to afford partial protection, and again more than in one of "temporary" resistance. Thus, whilst terra-cotta was useful for affording temporary protection in domestic buildings and the like, and certainly formed a far better partition than the old-fashioned stud partition, it was of little use for the more dangerous class of buildings. The experience of actual fires in Europe and in the United States had gone to show this through the thorough investigations that had been made by Professor Woolson, of New York, and of the Chicago Laboratories of the American underwriters, as also those of the British Fire Prevention Committee, to which Mr. Humphrey had referred.

Taken all in all, there was no doubt that if they weighed up questions of economy, practice, utility, and so on, a properly designed and properly constituted concrete would afford the most practical fire resistance that could be got at the present day. And it would certainly be most welcome if among the subjects that the Concrete Institute took up were how to help the Fire Prevention Committee in their serious inquiry into certain phases of the fire resistance of concrete which had not yet been fully entered into.

As Mr. Humphrey had said, however, even concrete structural features required "fire-proofing." A reinforced concrete beam, with its metal work partially protected with half an inch or an inch of concrete, was not a fire-resisting structural feature of any very great moment. Experiment and experience had both shown that for a practical beam of anything over 10 ft. span at least two inches of protective concrete of proper aggregates were required to protect the steel members. Should this not be possible or practicable to obtain, or should in very large beams only two inches be given, then they must think of protecting that actual beam with another fire-resisting curtain or coating. Whether that coating were in the form of a plastic material, an asbestos plaster, or what he believed was being used at the present moment in the United States, a kind of pumice covering or cinder covering, no matter; but some kind of covering was certainly required for these very large reinforced concrete girders, which showed all too little protection at the moment to their metal members. Where the fashion had come from of not protecting the metal sufficiently he did not quite know, but he was afraid it came, to a certain extent, from France and Belgium.

As to the general features of fire protection in the United States, as compared with those in England, they had one very great advantage in the Metropolis in rigidly limiting the cubic extent of their buildings. Until recently this was most strictly enforced. Now, with the tendency to build large stores and larger workshops, powers had been obtained through Parliament to extend the limits to a certain extent, and they were being so extended in many instances. A note of warning should here be sounded that the limits should not be extended too liberally.

The other great safeguard in London was certainly their height limit, and the fact that in the new high buildings the two floors and the roof had to be of fire-resisting construction.

Then, another great safeguard was the splendid way in which the Regulations as to party walls had been perfectly enforced ever since 1853.

On top of these structural safeguards they had one other safeguard which played an important part. He believed they paid more attention to the safety of the life of the human being in this country than perhaps in any other country. Life counted for more. With this provision for the safeguarding of life, they had received many regulations specifically intended in the first instance to save life—like the provision of exits, staircases, and so on, and these all made towards better building construction as a whole.

In those four points he thought they had a certain advantage, and it was to be hoped that some of these points which Mr. Humphrey had been studying in England and on the Continent would be embodied in that great Building Act in New York, which was now being worked upon, and drafts of certain portions of which the British Fire Prevention Committee and he himself had been honoured with for their observations a short time ago.

They had to thank the United States, however, for a great many things in the development of their building construction of late years. They had to thank them largely for a number of the better constructed floors that they had got over from the United States, quite a number of doors, and also for the more general use of wire-glazing.

He asked them to accord Mr. Humphrey their very best thanks for coming over and speaking to them in such a very delightful and interesting manner.

Mr. E. Fiander Etchells, F.Phys.Soc., in seconding the vote of thanks, remarked that, with regard to the low loss of life in London, it was largely due to the provision of suitable means of escape, quite apart from the question of the construction of the building, and he had generally found that the loss of life had been due to the contents of the building. For instance, in the Clapham Junction fire, and also the one the previous night in the Walworth Road, no matter how " fireproof " a building might be, the owners, for the best of reasons in this world, crammed as much goods into the shop as possible, so that the passages were only two or three feet wide. The position of affairs is such that when one lot of goods took fire, it immediately spread to the next lot. This question of getting fire protection for the contents of the building was so intimately connected with the question of rental values, the desirability of getting the most out of any given premises, that absolute fire prevention, he feared, was almost impossible.

As to the question of " fire resistance," as a term, instead of " fireproof," as a matter of fact, in all recent legislation fire resistance was spoken of, and not " fireproof," because it was generally recognised now that fire resistance itself was merely a relative term, and they had only to get a high enough temperature and any material would melt.

With regard to some of the illustrations he was very pleased to notice a great number of them where the pillars had failed with an absolutely central load. He had often wondered to what extent in buildings the theoretical assumption of central loading would take place, but they had had quite a number of instances of central loading, and that gave them all the greater confidence in dealing with their calculations.

Another feature noticeable in the illustrations was the superior advantage of the solid casing against the tiling, and he was of opinion that part of the expansion in the tiles was not only the expansion of air in the casing, or behind the tile, but was also due to the increased longitudinal expansion of the tile, and, as the length was limited from the ceiling to the floor and the tiles must expand in length, they bulged out just as railway lines had been known to do in hot weather.

After seeing the illustrations, he felt rather satisfied that they had in this country certain limitations as to the floor area. But, with all their limitations, it did not follow that they should inflict any great hardship on building owners, because they provided fire-resisting doors in between the separate divisions of the building. There was practically no limit to the cubic extent they could obtain and still comply with the regulations.

In conclusion, he desired to ask a question of Mr. Humphrey. Mr. Sachs had told us that he considered two inches of protection the minimum for reinforced concrete. Mr. Sachs' experience had been largely in England and various parts of the Continent, in the North of Russia and as far South as Egypt, which was, of course, on the edge of the Continent, and Mr. Humphrey's experience had been gained in America. He wished to inquire what was Mr. Humphrey's own opinion as to what should be a good amount of cover or protection in the case of pillars, beams and slabs respectively?

Mr. William G. Kirkaldy, Assoc.M.Inst.C.E., said he had been very interested in the slides Mr. Humphrey had shown. The effect of the fire on terra-cotta tiles had been very striking to him. He thought previously that terra-cotta would make a very fair protection, but evidently that was not so, seeing so many columns very bulged. He thought terra-cotta should be avoided after so many cases as they had seen on the screen; concrete was a far more promising thing.

Mr. E. P. Wells, J.P.: Mr. Humphrey had convinced him of the wisdom of what the London County Council had done in passing the 1909 Act, with this difference, that the Council, in certain stringent provisions that were laid down in that Act, were not stringent enough. He had proved, especially in column construction and the encasing of fire-resisting materials, that if they wanted to protect a steel stanchion absolutely from danger in case of fire, it ought to be covered with an absolute minimum thickness of 3 ins. of concrete, and that in no case should any casing of what were known as plaster partitions be permitted; that it should in all cases be concrete, or brickwork set in cement. Where concrete was filled in between the tiles and the body of the stanchion, in 99 cases out of 100 it was of a very inferior nature, but in the casing of stanchions to make them absolutely fire-resisting, or as near fire-resisting as possible, the concrete ought to be of a very much richer nature than was generally used, the aggregate used should be of a very fine description, and in no case should any aggregate be allowed in a casing larger than about half an inch. It is no uncommon thing, and I have seen this since the passing of the 1909 Act, to encase a stanchion with an aggregate which is made from broken brick and other similar materials, which is passed through a 2-inch ring. Now, in the case of that kind, which was very often done, especially in London, where there was an insufficiency of sand, it became an absolute physical impossibility with a concrete of such a nature to make it fire-resisting, because it is extremely porous. Such being the case, it followed that heat readily finds its way on to the steel. This applied not only to stanchions, but also in the casing of steel beams.

Another point he was pleased Mr. Humphrey mentioned was what he (Mr. Wells) had adopted for several years past, where he had been compelled to use cast-iron columns in construction—namely, to fill all the columns with concrete. And in any case of strengthening an existing structure when cast-iron columns had been used, he had always recommended at the first outset that the columns be filled with concrete, and if he could put a reinforcing of concrete down the centre so much the better, because he knew from experience that the columns would stand when the cast-iron failed.

The Chairman, in putting the vote of thanks to the meeting, expressed his indebtedness to Mr. Humphrey for the very interesting observations that he had made, and also for the thoughts that he had raised. He agreed with what had been said about tile-casing. He never did like tile-casings, and he had never used them, and the results of these fires had shown how very little they were to be relied upon.

THE LECTURER REPLIES.

Mr. Humphrey, in replying, observed that in England the British Fire Prevention Committee had been engaged in studying the relative fire resistance of materials at their testing station and in Germany and Austria. Small test-houses had been made and small floors had been constructed, and fires built in them, both with load and without load, and tested. All this work had been most excellent in developing the relative fire resistance of materials and the comparative value of various forms of "fireproofing." In many tests the first experiment has failed, but in the test those interested had learned a certain amount of wisdom, and thus in the second test a better article was produced which passed muster.

First they must know the relative fire resistance of materials; secondly, the relative fire resistance of concrete with various aggregates; but the most important thing that they did not know was the behaviour of a structure, as a whole, in a conflagration. If they could conceive of a warehouse of large extent, with a contents of perhaps wall-paper or cotton, and consider that a fire occurred in the centre, an intense heat was generated, what happened to that structure? The parts immediately in proximity to the fire were expanded by the heat, but the free expansion of that ceiling had been resisted by the cooler masses that surrounded them, and they got the fact of a great force being exerted in that structure by reason of the expansion, and the tendency was inevitably to strip off the concrete or the fire protection on the steel, or whatever the structure that carried that load.

In his judgment, a most important thing in the building in fireproofing was the study of the expansion of the structure as a whole, and the value of taking a large floor area and breaking it up into 5,000 sq. ft. or 10,000 sq. ft. was that they reduced the amount of area that could be subjected to that expansion.

Mr. Etchells had asked what amount of protection was necessary in the case of a reinforced concrete column? It was frequently the practice to put 2 in. of concrete on the outside of the reinforcement and 1½ in. on girders and ¾ in. on slabs. It, however, depended largely on how the steel in the structure was insulated. If in the course of construction there was a direct connection by some steel bar that brought the steel in contact with the air, no amount of protective coating would protect that steel, because the heat was transmitted through that bar and the steel, expanding, simply stripped the column.

He was of opinion that the best way to protect that column was to put round a metal fabric which would distribute the expansion of the concrete mass, and then perhaps a lesser thickness than 2 in. was possible. But they could not lay down any hard and fast rule as to how thick that should be. A building which contained merely office furniture did not require as much protection as a warehouse, and they must gauge the amount of protective coating on the structural member by the character of the contents that must go into the building. The American Committee on Concrete had prescribed 2 in. on columns, 1½ in. on beams and girders, and 1 in. to ¾ in. on slabs, and he thought that was quite sufficient.

His experience in studying the penetration of heat in fires, and in the tests which were made by the American Government of surfaces subjected to heat, was that in ordinary concrete and with temperatures that were well beyond what might be expected in an ordinary fire, the penetration of heat rarely exceeded three-quarters of an inch, and in most conditions it only penetrated perhaps half an inch.

This brought up a subject which had been frequently discussed, the value of material like limestone as an aggregate in a fireproof concrete. If they took limestone and kept the sand away from the surface and had a protective coating of silicious mortar in front of it, that limestone was just as good a medium for a fire protective coating of concrete as other material. It was infinitely better than granite or gravel. But if the limestone was subjected to the direct action of the flames, the limestone was decomposed by the driving off of a carbonic acid gas, and if water came in contact with that lime or with the ceiling, it disintegrated the surface.

They had a method of fireproofing which was being gradually developed in America in which cinders were used as the aggregate of concrete. Of course, there were all sorts and conditions of cinders, and the definition of the word "cinder" itself was very elastic and ambiguous. But if they took cinder as meaning a clinker, and not the ordinary soft kind of ashes from the furnace, that was clean and free from sulphur, and mixed that up with cement, they got a material of very high fire resistance, and if that material was put round as a protecting feature for a column or a girder they got a substance of superior excellence.

They must never concrete a material which had a low absorption, and the harder and the denser the aggregate, the better was the concrete.

The protection of the imbedded steel with a reasonable thickness of concrete was desirable, but he believed that the problem of keeping the contents of a building segregated in small units of very small floor space—and he should say not more than 5,000 sq. ft.—with properly protected fire doors and fire walls, was the main essential in a building. Where they had a conflagration it did not matter how thick the protective covering was if they had an enormous flat surface subject to that heat, the expansion of that material would undoubtedly strip the protective coating. In the case of concrete, the expansion of that tile was not so much the expansion of the air, which was made possible by defects in the tile itself, but it was the fact that terra-cotta had a much greater expansion under heat than concrete, and that a very thin web of perhaps $\frac{3}{4}$ of an inch expanded very rapidly, and the lower web, which was above, expanded less rapidly, and they had a condition which intensified the expansion of the floor and the web simply dropped off.

The points raised by Mr. Sachs were being considered largely in America. They did lose a great many people by fire, and there was apparently a carelessness, but they must bear in mind that they had a condition that was the outgrowth of a very young country. While England reckoned her civilisation by thousands of years, America reckons hers by hundreds, and they had barely outgrown the frame shanties of the pioneers that settled in America, and it was the gradual elimination of these frame buildings, that were such a menace to their population, that was commending their study to-day. The law was getting stricter, and it was in this study and this evolution that some of the good things that Mr. Sachs had stated had been evolved. They still had many bad things, and they looked to Europe and to England for a great deal of help in the solution of this very important problem.

The proceedings then terminated.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

SOME OF THE PROPERTIES OF OIL-MIXED PORTLAND CEMENT MORTAR AND CONCRETE.

By Mr. LOGAN W. PAGE, M.Am.Soc.C.E.
(Director of Public Roads, U.S.A.)

The following abstract is from a paper presented to the American Society of Civil Engineers on November 1st, 1911, and which was published in the Proceedings of that Society in September, 1911.

MR. PAGE found some time ago that oil in considerable quantities could be combined with wet Portland cement paste by a simple mixing process. When oil was added to the wet cement it disappeared completely when mixed for a few minutes, and, furthermore, there was no apparent separation of the ingredients upon setting. Tests were made with various kinds of oil and various mixtures of cement, mortar and concrete, the tensile strength of neat cement and mortar, the time of setting, the crushing strength of mortar and concrete, and tests for permeability.

The materials used consisted of Portland cement, river sand and $\frac{3}{4}$-in. crusher run-gneiss. The cement complied with the specifications recommended by the Special Committee on Concrete and Reinforced Concrete.

Method of Mixing.—The following method of mixing was used: The proper quantities of cement and sand were mixed dry until of uniform colour. Water was then added and the mass was turned as often as was necessary to produce a rather wet mortar. The water added to the mortar was not weighed, the appearance of the mix being the criterion for determining the proper quantity. In general, however, the total quantity of water, including that in the sand, was about 17 per cent. of the total weight of the cement and sand. After having mixed the mortar, the desired quantity of oil was added, and the mass was turned over as many times as was necessary to break up the oil and incorporate it thoroughly with the other ingredients

The previously moistened stone and the oil-cement mortar were then combined and turned until thoroughly mixed. The percentage of water required to make a rather soft mixture was determined from the appearance of the first batch.

While the tests were still in an incomplete state, the writer published them in order to give publicity to the results already obtained, so that engineers with better facilities may hasten the work through its experimental stage.

The service tests are of a special interest in that they were conducted on actual construction. During April and May, 1910, two bridge surfaces of oil-concrete were laid at Ridgewood, N.J. In the borough of Richmond, New York City, during May and June, 1910, about 400 ft. of street surface was laid with different aggregates. About 300 ft. of street in Washington, D.C., was surfaced in June, 1910. On another page of this issue will be found a Progress report of this experiment, with results that have been gained in dust prevention and road preservation. Numerous inspections of this work have been made and up to the present it is all in very good condition. About one-half mile of roadway laid with 10 per cent. oil-concrete in the suburbs of Harrisburg, Pa., in the summer of 1910, is also reported to be in very good condition.

A vault 112 ft. long and 18 ft. wide in the United States Treasury Department was built in the autumn of 1910. The side walls of this vault contained 10 per cent. of oil. Its roof was constructed of ordinary reinforced concrete, with about 3 in. of 10 per cent. oil-concrete on top. For several months this roof was subjected to a head of water of several feet without showing any signs of leakage. Another vault, in the north end of the Treasury, on account of leakage has never been available for storing anything of value. Its roof was treated with oil-concrete, and is now perfectly dry. Numerous floors in the sub-basement of the Treasury Department, and a floor in the office of Public Roads, have been constructed with 10 per cent. oil-concrete, and have remained absolutely free from dampness. A tank, about 12 ft. long, 4 ft. wide, and 4½ ft. high, constructed in the office of Public Roads during the winter of 1910, has been continually full of water, and has not shown the slightest signs of leakage.

Summary of Conclusions.—The following tentative conclusions as to the effect of the oils used in cement and concrete may be drawn from the foregoing investigations:—

1. The tensile strength of 1 : 3 oil-mixed mortar differs very little from that of plain mortar, and shows a substantial gain in strength at twenty-eight days and six months over that at seven days.
2. The times of initial and final set are delayed by the addition of oil, 10 per cent. of oil increasing the time of initial set by 90 per cent., and the time of final set by 60 per cent.
3. The crushing strength of mortar and concrete is decreased by the addition of oil to the mix, concrete with 10 per cent. of oil having roughtly 75 per cent. of the strength of plain concrete at twenty-eight days. At the age of one year the crushing strength of 1 : 3 mortar suffers but little with the addition of oil in quantities up to 10 per cent.
4. The toughness of resistance to impact is affected but slightly by the addition of oil in quantities up to about 10 per cent.
5. The stiffness of oil-mixed concrete appears to differ but little from that of plain concrete.
6. The results of tests for permanent deformation do not indicate that a law is followed by oil-mixed concrete.
7. Oil-mixed mortar and concrete containing 10 per cent. of oil have very little absorption, and under low pressures both are waterproof.
8. Oil-mixed mortar containing 10 per cent. of oil is absolutely watertight under pressures as high as 40 lb. per sq. in. Tests indicate that oil-mixed mortar is effective as a waterproofing agent when plastered or painted on either side of porous concrete.
9. Bond tests show the inadvisability of using plain bar reinforcement with oil-concrete mixtures. With deformed bars the bond is not weakened seriously by the addition of oil in quantities up to 10 per cent.

A patent has been granted to the writer for mixing oil with Portland cement concrete and hydraulic cements giving an alkaline reaction. All citizens of the United States are at liberty to use this process without the payment of royalties.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

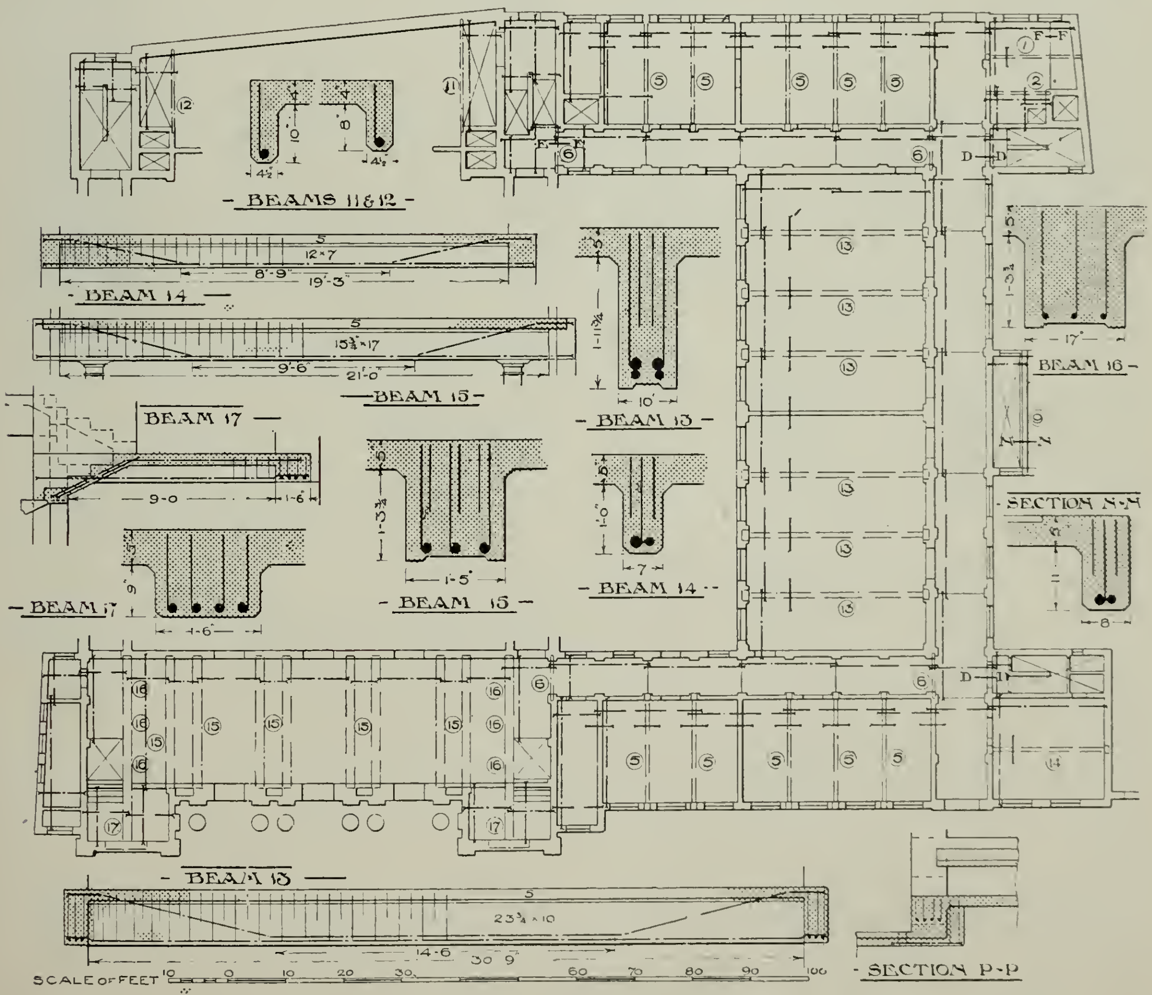
BURSLEM PUBLIC BUILDINGS.

We are illustrating in this article a particularly fine example of reinforced concrete as applied to buildings of the municipal type. The drawings herewith show many important features in construction, and a view of the exterior of this imposing structure will be seen in the frontispiece to this issue.

The floors, beams, and staircases throughout were of reinforced concrete as well as the gallery to the winter garden.

The overall dimensions of the building are 165 ft. by 140 ft.; total height from foundations to ridge 64 ft.

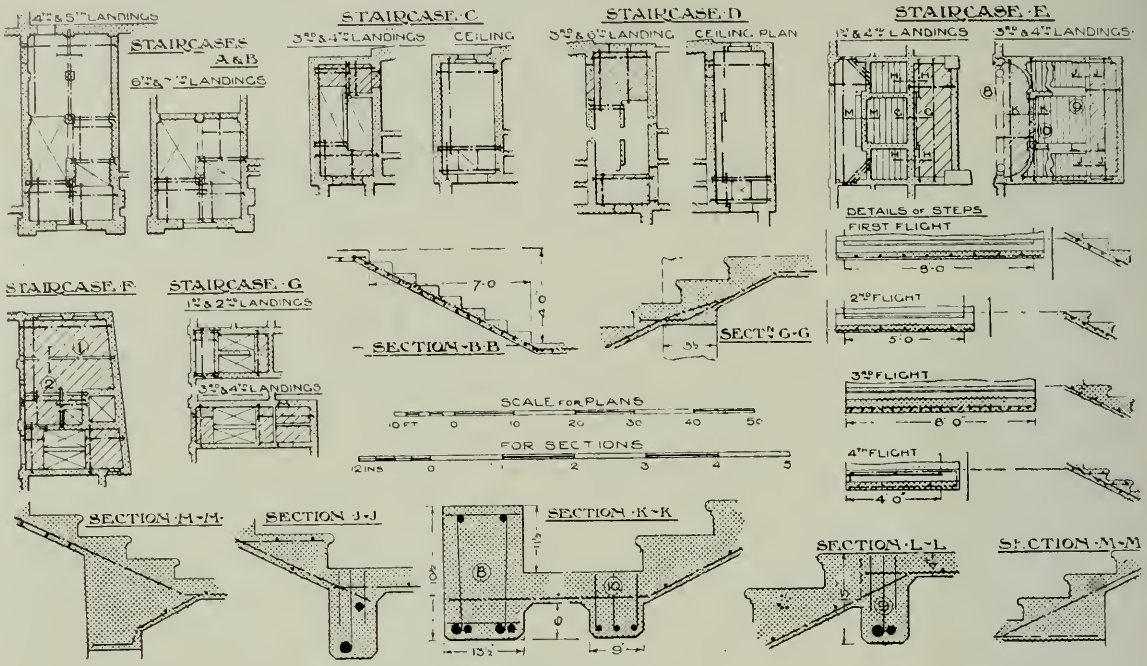
The dominant point throughout was the limitation of the beams to as shallow



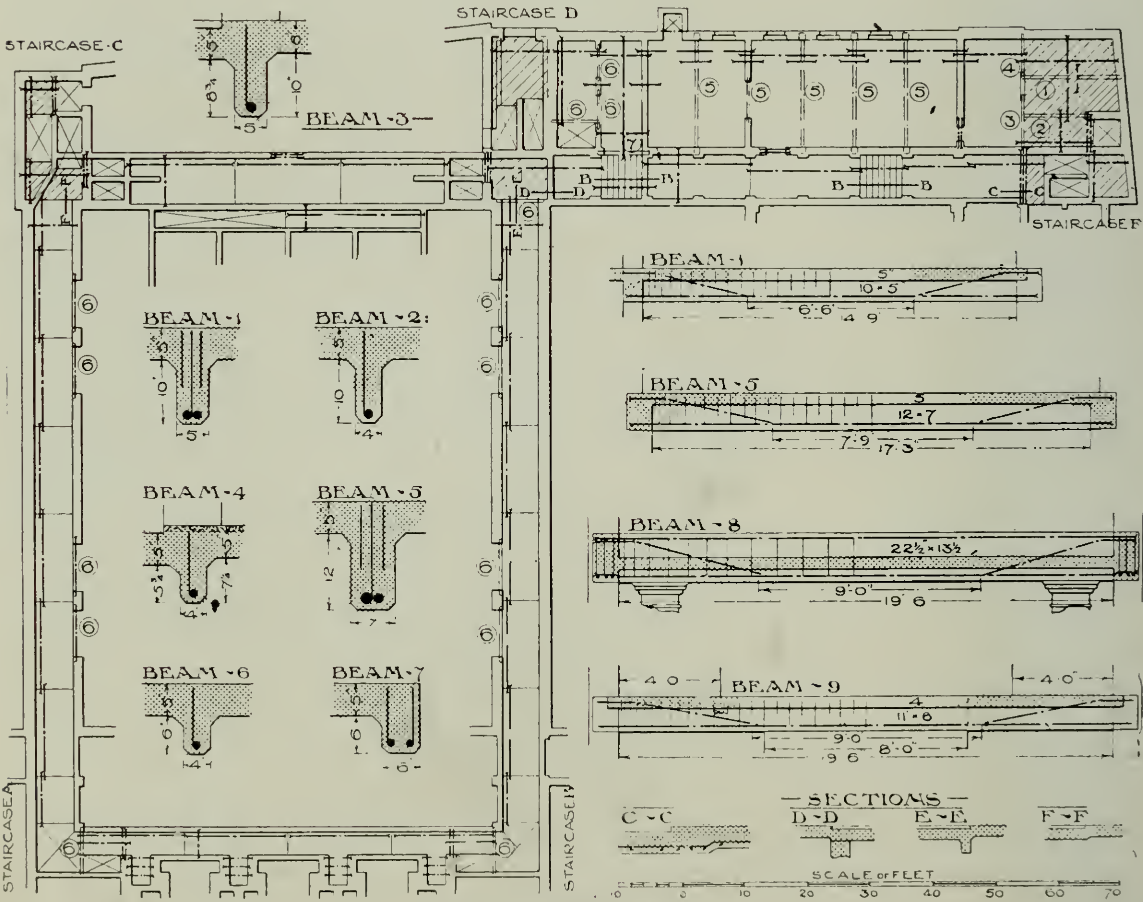
Details of ground floor, showing construction of first floor.

Burslem Public Buildings,

a depth as possible, whilst the floors were to be as thin as could be consistent with safe construction. The biggest span was 31 ft. 6 in. The loadings in all cases were taken at 2 cwt. per ft. super, inclusive of the static or dead-weight.



Details of stairs.

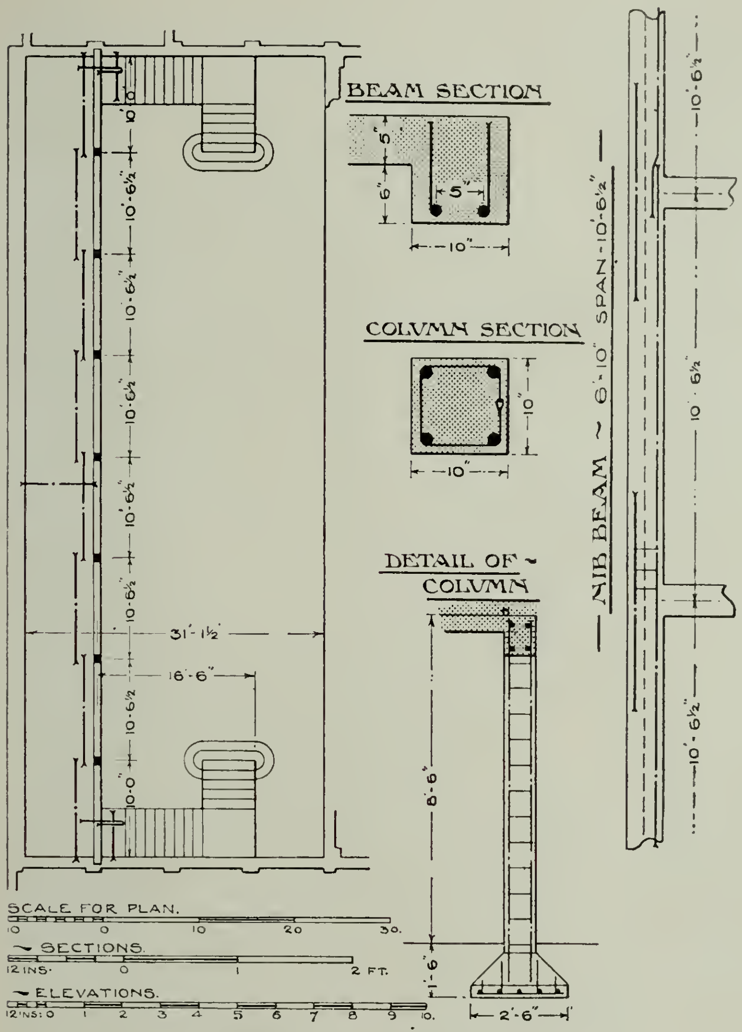


Details of staircases and beams.
Burslem Public Buildings.

The surface of the floors was floated to receive marble, wood block, or mosaic. Ceilings were prepared in some cases for fibrous plaster: in others they were simply rendered over with a $\frac{1}{4}$-in. skimming coat.

The staircases—seven in number—were all constructed of reinforced concrete. The principal staircase was left ready to receive marble finish, the secondary ones having a patent granolithic finish.

The contractors for the work were Messrs. Stuart's Granolithic Co., of 4 Fenchurch Street, London, E.C., and their consulting engineer was Mr. E. P. Wells, of Larkhall Rise, Clapham, S.W., who drew up the plans for the reinforced concrete work. The architects were Messrs. Russell & Cooper, of Gray's Inn Square, under whose direction and close supervision the whole of the work was executed.



Details of gallery to Winter Garden.
BURSLEM PUBLIC BUILDINGS.

REINFORCED CONCRETE SEDIMENTATION TANKS, BELFAST.

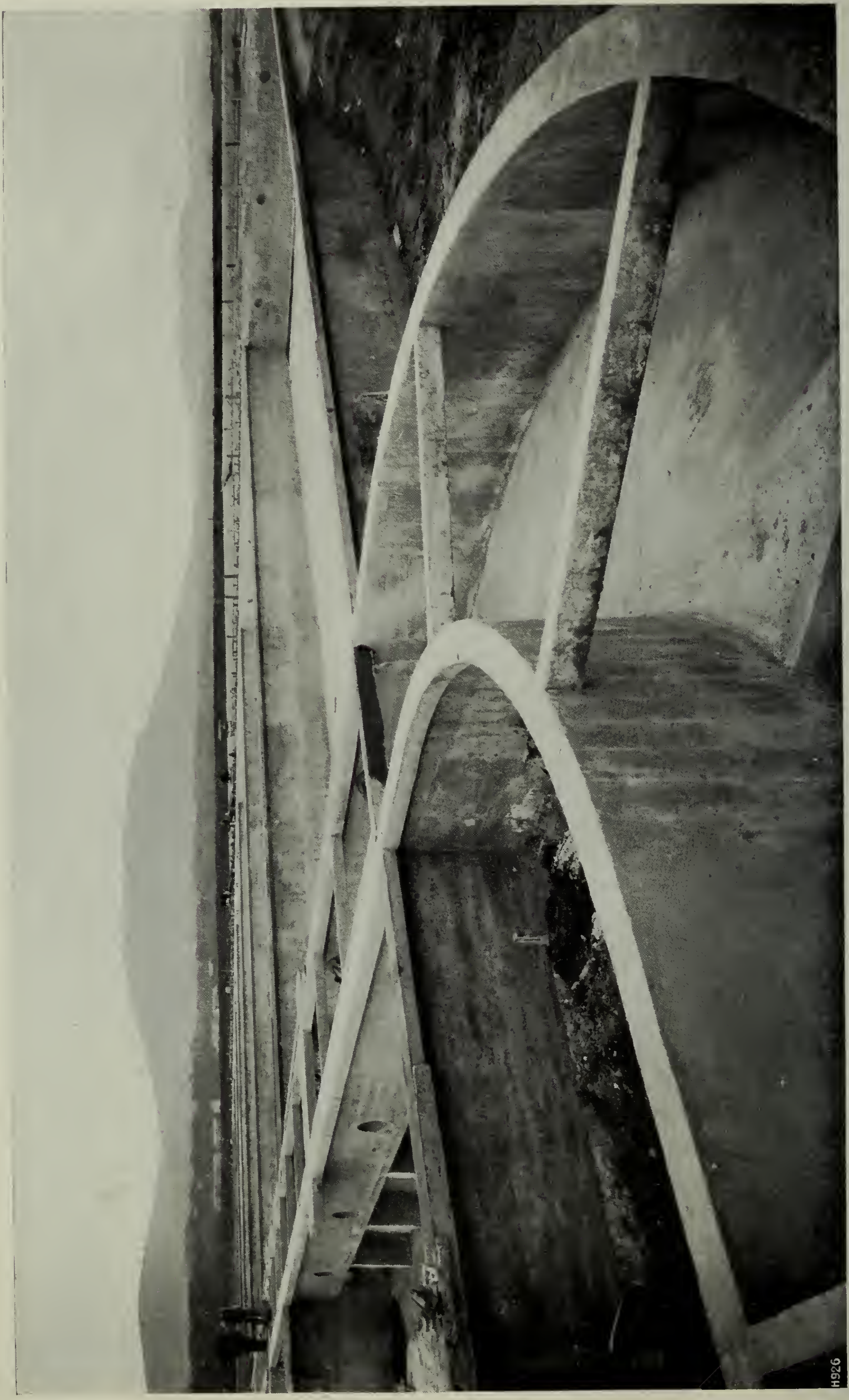
THE Corporation of Belfast have recently been much before the public in connection with the disposal of the sewerage of their city. The whole subject has been argued before a Royal Commission, and more recently before a Parliamentary Committee, in connection with the presentation of the Befast Corporation Bill.

One important recommendation of the Royal Commission has been met by the completion of an extensive system of tanks, constructed in reinforced concrete and forming a reservoir of about 4,200,000 gals. capacity.

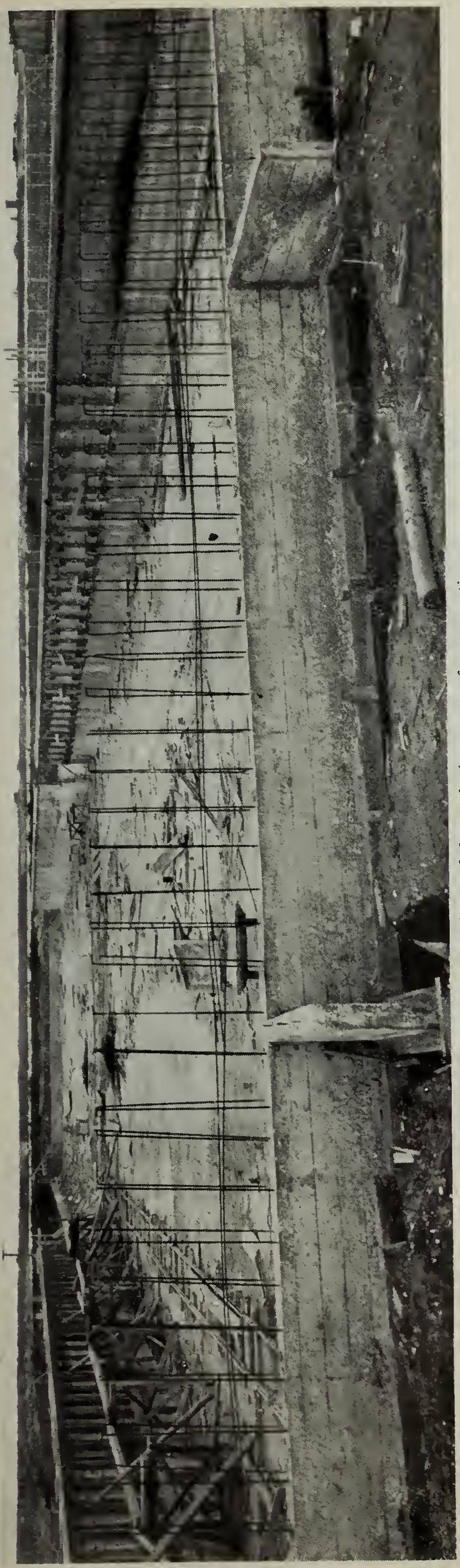
The tanks are fourteen in number, each 120 ft. by 60 ft. by 8 ft. deep, and arranged seven on each side of an elevated feed channel. The side walls of the feed channel are provided with penstock valves through which the sewage water is let into the tanks. When the water has been in the tanks for some time, the force of gravity separates the heavier substances, or the sludge, from the water. The sludge is then drawn out through a series of valves operated automatically by floating arms and located near the bottom of the tanks and in the walls of a sludge culvert, which is situated directly under the feed channel. The comparatively clean water above the sludge is drawn out through another series of penstock valves at a higher level into a draw-off channel that runs alongside the exterior walls of the tanks.

The reservoir is built on filled-in ground, and had therefore partly to be carried on piles from 30 ft. to 40 ft. long. The piles are spaced about 10-ft. centres each way and about 1,200 were put in.

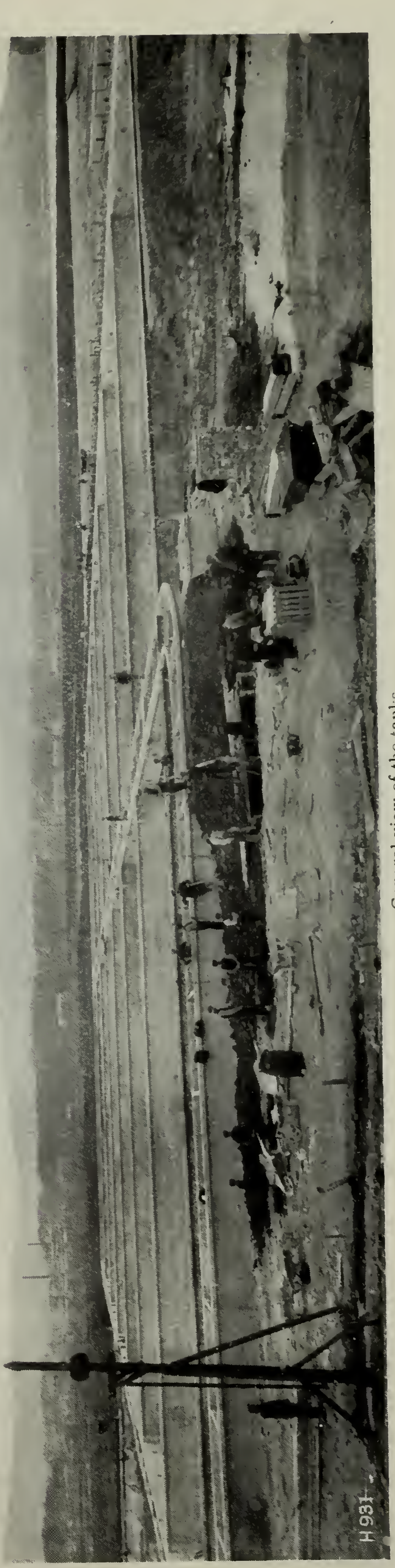
The work was executed to the plans and under the direction of the city engineer,



View showing tanks and centre-feed channel.
REINFORCED CONCRETE SEDIMENTATION TANKS, BELFAST.



View of one of the tanks in course of construction.



General view of the tanks.

REINFORCED CONCRETE SEDIMENTATION TANKS, BELFAST.

Mr. H. A. Cutler, M.Inst.C.E., by Messrs. J. & W. Stewart, specialising contractors for reinforced concrete construction and concrete piling, of London, Belfast, Glasgow, and Dublin.

Designs to meet the city engineer's requirements and specifications were called for, and although the tender of the successful firm of contractors was not the lowest, their design secured for them the contract, which was completed satisfactorily in the short period of fifteen months.

REINFORCED CONCRETE BATTERY ROOM FOR THE NORWICH ELECTRICITY WORKS.

A NEW battery room has recently been added to the Norwich Electricity Works, and after exhaustive inquiry, the engineer to the Corporation electricity undertaking, Mr. Long, A.M.Inst.C.E., adopted the Kahn system of reinforced concrete.

The building is roughly rectangular in plan, the mean depth being 34 ft., and the mean width 54 ft.

Interior of battery room during construction.

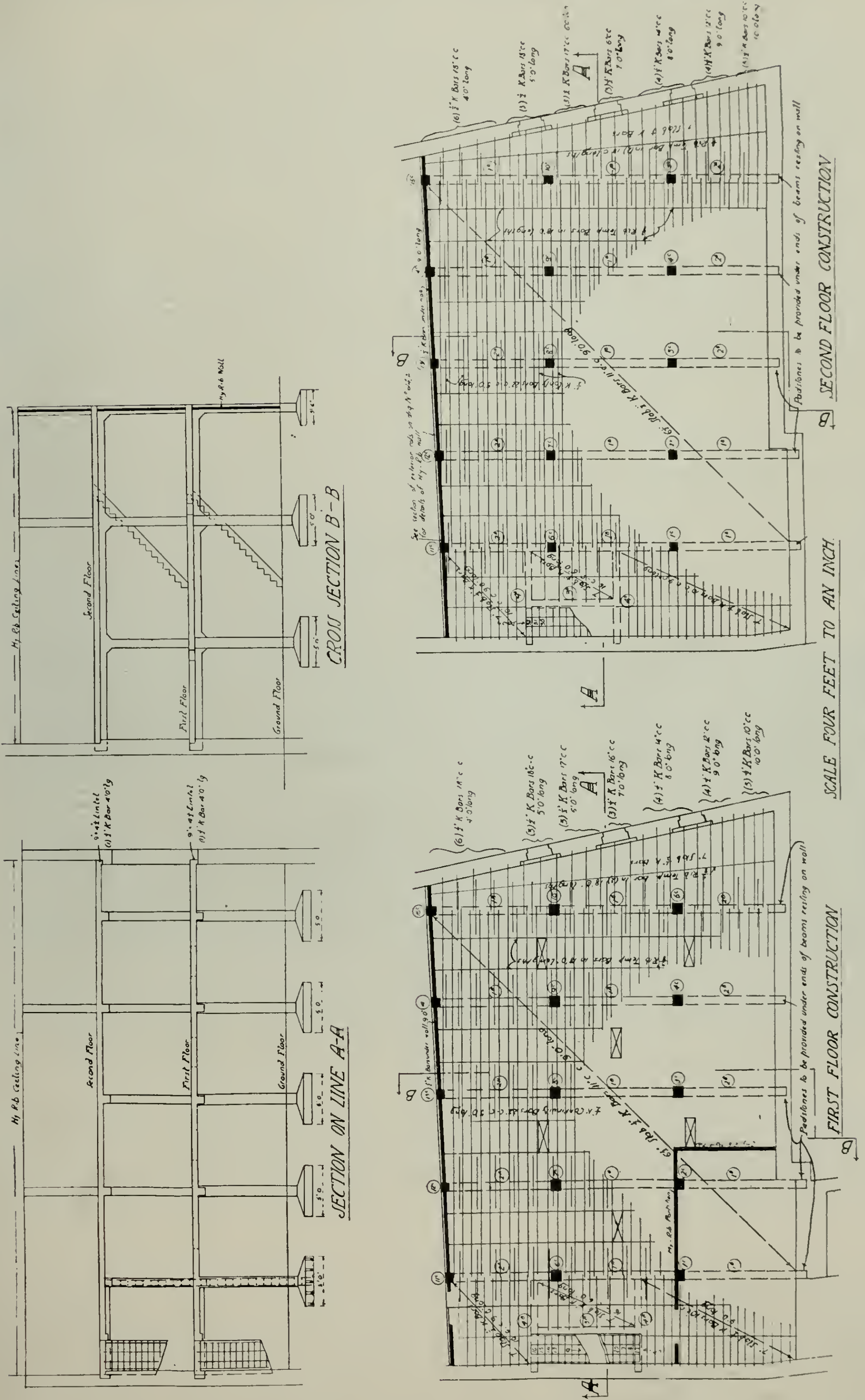
REINFORCED CONCRETE BATTERY ROOM FOR THE NORWICH ELECTRICITY WORKS.

The column bases are composed of 5-ft. 6-in. square concrete blocks, 18 in. deep, reinforced with ¾-in. Kahn bars 4 ft. 8 in. long. The columns to first floor are 12 in. square, reinforced with No. 4 1-in. rib bars 12 ft. 8 in. long, wired to No. 4 1-in rib bar splicing pieces 3 ft. long, at a distance of 9 ft. centre to centre. The columns to the second floor are 10 in. square, reinforced with ½-in. rib bars 10 ft. 8 in. long, spliced to first floor columns, 9 ft. centre to centre. All sets of column bars have 3/16 ties 9 in. centre to centre.

The beams are 15 in. by 10 in., reinforced with 1-in. Kahn bars 12 ft. long, and ¾-in. rib bars 19 ft. long, and ¾-in. rib bars 17 ft. 8 in. long.

All concrete for beams and columns was mixed in the proportion of 4 : 2 : 1, the aggregate for these being of crushed gravel and of fine shingle for floor slabs.

The floor slabs are 6½ in. thick, reinforced with ½-in. bars 9 ft. long, with ½-in. continuity bars 5 ft. long, and ⅜-in. rib bars 9 ft. centre to centre.



Details of first and second floor construction.

Reinforced Concrete Battery Room for the Norwich Electricity Works.

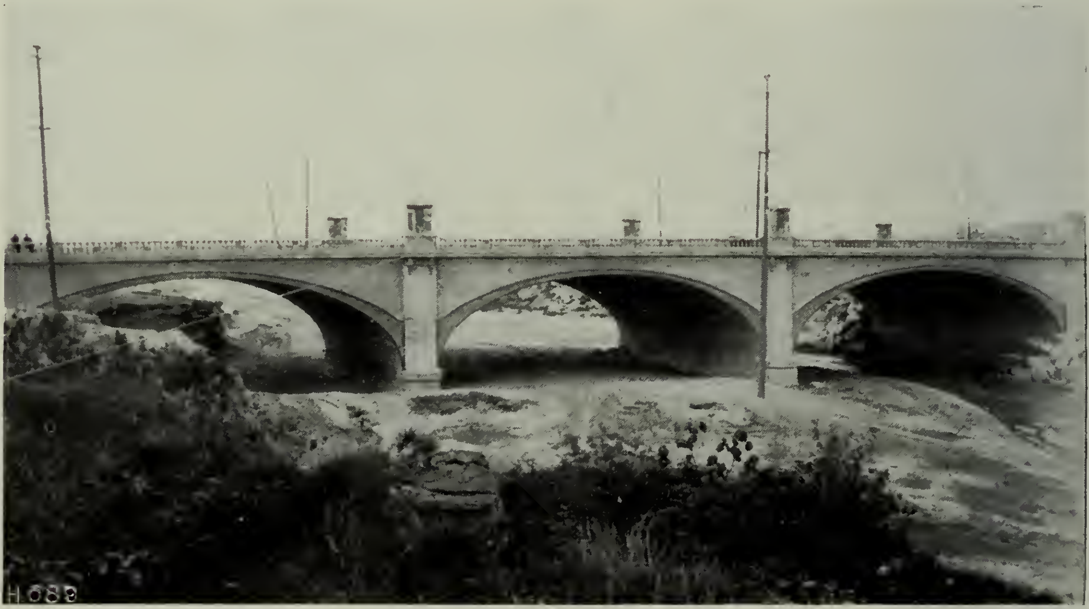
The ceiling is constructed of 28-in. gauge Hy-rib finished in cement plaster. The partitions are also formed of 28-in. gauge Hy-rib, reinforced with ¼-in. bars at 30-in. centres, finished in cement concrete 2½ in. thick. These partitions are a great feature of the work as their stiffness is equal to a 4½-in. wall in cement, and the cheapness and quickness of erection by this method was very marked.

The whole of the steel work used is medium open hearth steel of an ultimate strength of 60,000 lb. per sq. in., with a minimum elongation of 20 per cent.

Mr. A. H. Plouright, of 15 Haymarket, Norwich, acted as consulting engineer for the whole of the reinforced concrete work, Messrs. J. Youngs & Son, of Norwich, being the contractors. The work was carried out by unskilled labour, and has proved very satisfactory.

REINFORCED CONCRETE BRIDGE OVER LOS ANGELES RIVER.

THE reinforced concrete bridge over the Los Angeles river, Los Angeles, Cal., described in this article, takes the place of a wooden bridge which had been constructed temporarily. The new bridge is 320 ft. long, exclusive of approaches, and 75 ft. wide. It provides for pedestrian and vehicle traffic, and carries a double-track electric street railway line. It is a 3-span structure, each span being 80 ft., with a rise of 21 ft. The foundations are carried 25 ft. down below the river bed, and rest on 500 piles. The footings were laid in 15 ft. of water, and have the following dimensions : Pier footings, 20 ft. wide by 75 ft. long—the width of the bridge ; abutment footings, 27 ft. wide and 75 ft. long. The shafts have a halter of ½ in. per ft., making a width at top of 8 ft.



REINFORCED CONCRETE BRIDGE OVER LOS ANGELES RIVER, LOS ANGELES, CAL.

In the construction a total of 5,000 cubic yards of concrete were required. The reinforcement used is plain and twisted steel of various diameters.

The construction of this bridge was carried out under the direction of Mr. Homer Hamlin, City Engineer of Los Angeles.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork where structures of great height are required.—ED.

REINFORCED CONCRETE FENCE POSTS ON THE LONDON AND NORTH-WESTERN RAILWAY.

WE are frequently pointing out the advantages of reinforced concrete fence posts and the benefits to be gained by their use are evidently appreciated by many of the leading railway companies in this country, as they are gradually replacing the timber posts on their lines by those made of reinforced concrete.

Three miles of reinforced concrete fencing, a portion of which is shown in the illustration on this page, were recently constructed for the London and North Western Railway Co. by the Reinforced Concrete Fence Posts Co., Ltd., of West Mill, Buntingford, Herts. These posts are the registered designs of this company, and we understand that they are erecting them all over the country, great satisfaction having been experienced wherever they have been used.

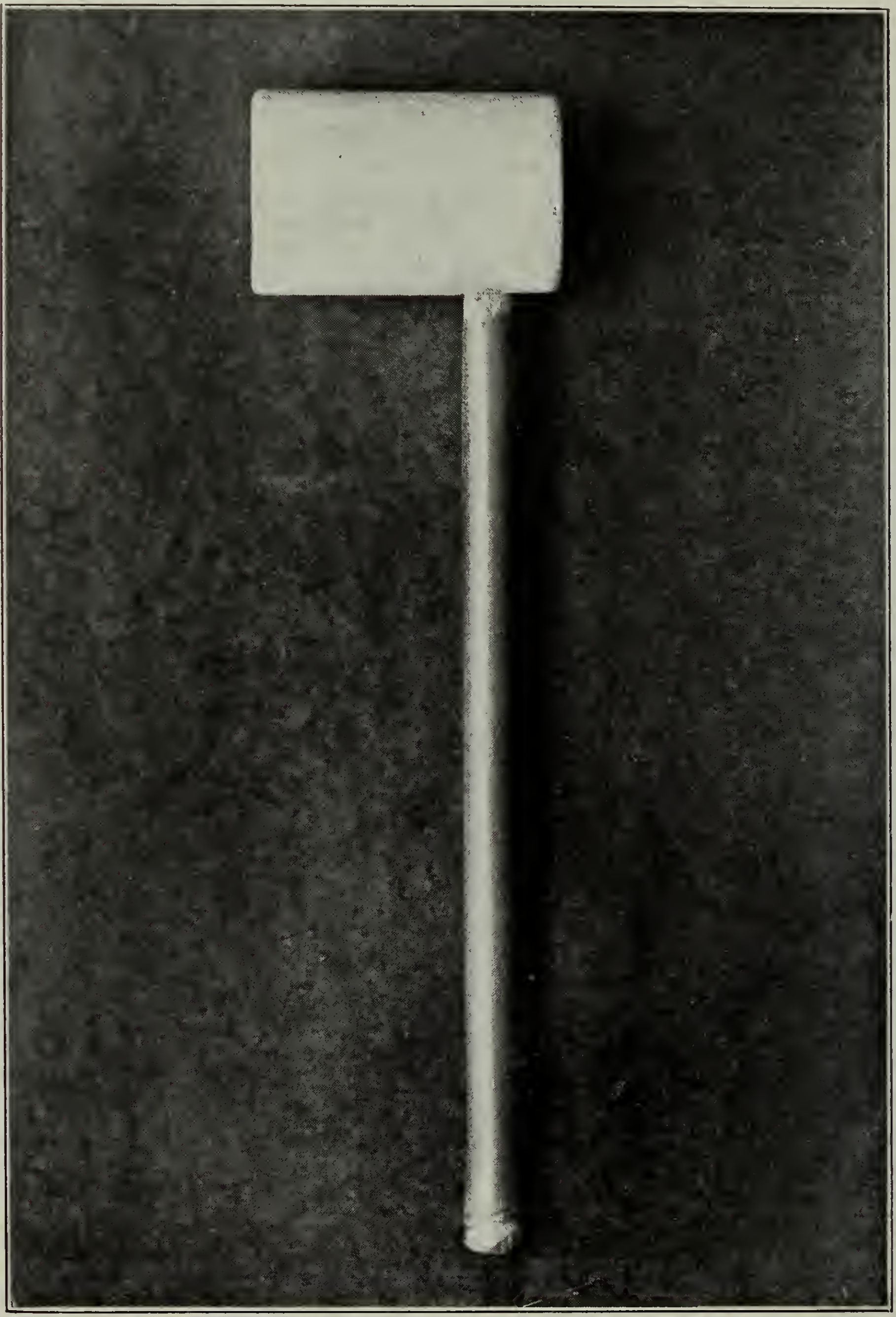
REINFORCED CONCRETE FENCE POSTS ON THE LONDON & NORTH WESTERN RAILWAY.

A CONCRETE PIPE.

A VERY novel use to which concrete has been put is in the manufacture of pipes. Our contemporary, *The Concrete Age*, to whom we are indebted for our illustration, recently described this new industry, which has been started at Roxcroft, Maine, U.S.A., where Mr. B. T. Genthner has invented a new process of pipe manufacture, known as the " Everlasting Pipe."

The patent consists of a wire coil moulded in the stem socket as a reinforcement.

The composition is pure asbestos, with sufficient Portland cement to concrete it, and by this method an almost indestructible pipe is obtained. The asbestos and cement are mixed together, the resulting mortar being formed into blocks and then placed in a machine where the pipes are moulded and turned. They are then laid in piles and kept moistened for two weeks, after which they are filed and polished, and are then ready for use. The output is 1,650 pipes a day, and at present the American Tobacco Co. are taking over the entire production.



"The Everlasting Pipe," made of Asbestos and Portland Cement reinforced with a Wire Coil in the Socket.

A Concrete Pipe.

NEW BOOKS

AT HOME AND ABROAD.

A short summary of some of the leading books which have appeared during the last few months.

"Reinforced Concrete Design Simplified." By John C. Gammon, ***B.Sc.*****, with an Introduction by H. Kempton Dyson,** *Secretary of the Concrete Institute.*

London: Crosby Lockwood & Sons. Demy 4to, cloth, 122 pages, with Thumb Index. Price 10/6 net.

Contents.—Introduction—Method of Calculations, etc.—Bending Moments and Shearing Forces—Design of Slabs — Design of Rectangular Beams—Design of T-Beams—Web Reinforcements—Design of Rectangular Columns—Cost of Concrete—Super-imposed Loads on Floors—Weight of Floor Slabs of Various Thicknesses per sq. ft. — Areas, Weights and Spacing of Rods.

The main features of this volume are the labour-saving diagrams, which are so varied that the design of slabs, beams or columns for any particular span, load or limiting stress can be effected without the complicated calculations that are usually necessary. There is no doubt that the adoption of diagrams to facilitate the design of reinforced concrete will become more or less general in the future, as the tendency everywhere is to save time and produce schemes at the shortest possible notice, and the designer is practically forced to employ methods far different from the easy-going type of a few years ago. It is a curious thing that any client who has an idea of carrying out a scheme will probably spend many weeks or months in making up his mind as to whether or not he will proceed with the work, and yet, once he has decided to do so, nothing will satisfy him but that the whole of the drawings and work must be pushed forward and completed with lightning speed, with often far too little time to consider the scheme effectually. This fact leads to the adoption of rough and ready rules in the case of many designers in order to obtain only approximate results; and we agree with Mr. Dyson that it is far better to employ some aid in the design which will give accurate results with the minimum waste of time.

The diagrams are very good in the volume, and we go so far as saying they are the best we have seen, while the inclusion of the examples will give the user a good opportunity of realising the correct method of applying each particular diagram.

There is one danger that is likely to arise with the publication of diagrams for reinforced-concrete design, and that is the great possibility of architects or others who have not made a special study of the subject attempting to design reinforced-concrete work in a similar manner to that in which many steel-framed buildings have been designed in the past, and, in fact, are designed to-day. The loads are taken out approximately, and reference is made to one of the tables issued by the numerous steel-work firms, and a certain steel joist or girder selected, the designer in the majority of cases having a very limited knowledge of bending moments or safe stresses; while the term "moment of inertia," or similar definition, holds for him unknown terrors. We are afraid this is a danger that can hardly be avoided, and if tables are to be used in this manner it is of primary importance that they should at least be absolutely reliable and of such a nature that the possibility of error is reduced to a minimum. We can recommend this volume to our readers, and feel assured that the outlay entailed will very soon be repaid in the saving of time that will result from its use.

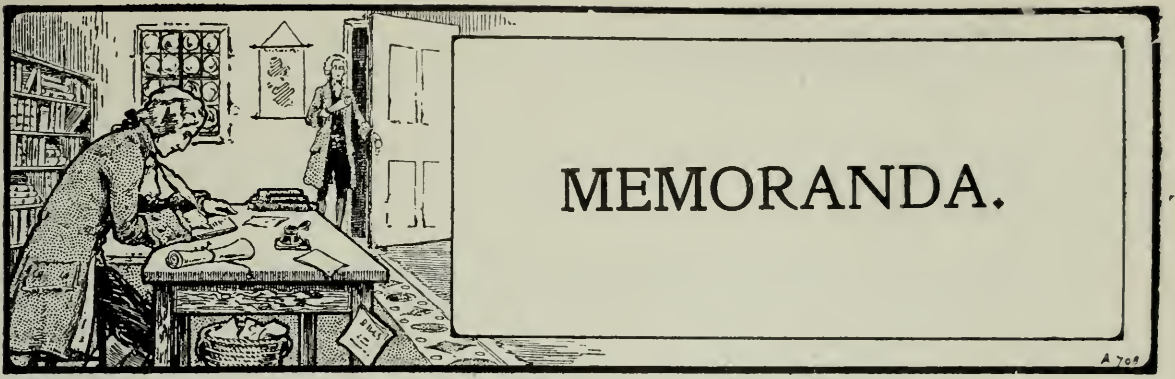
"A Manual of Civil Engineering Practice: Specially Arranged for the Use of Municipal and County Engineers." By F. Noel Taylor, ***M.Inst.M.E.***

London: Charles Griffin & Co., Ltd. xii.+810 pp. (8 in.×6 in.), with 35 Folding Plates. Price 25/- net.

Contents.—Index to Equations and Formulæ—Ordnance Maps—On Surveying with the Chain—Surveying with Angular Instruments — Levelling—Adjustment of Surveying and Levelling Instruments—The Measurement of Areas and Volumes, and the Calculation of Earthwork Quantities—The Mechanics of Engineering—Beams—Pillars and Stanchions and Shafting —On the Design of Engineering

Structures—Arches—Graphic Statics—Materials of Construction—Foundation and Pile-driving—Brickwork and Masonry — Walls — Constructional Carpentry—The Construction and Maintenance of Loads—The Design of Engineering Structures in Concrete - Steel — Masonry Bridges, Weirs and River Works—Hydraulics—Land Drainage—Pumping Machinery—The Use of Water Power—Main Drainage—Sewage Disposal—Royal Commission on Sewage Disposal—Engineer's Report to Local Government Board on the Salford Sewage Works — Sanitation and House Drainage—Refuse Disposal—Waterworks—Reservoir Construction—Waterworks Distribution—Brick and Steel Chimneys—Steel and Iron Construction and Design—Beams and Girders—Combined Structures in Iron and Steel—Specifications—Electric Tramways—Appendices—Index.

We are loth to criticise this book adversely, for it contains much valuable information, and is admirably got-up, containing a great number of pages at a very low price. The author deserves commendation for his industry in compiling such a wealth of information on all branches of such a wide subject which had not received separate treatment in the way it deserved, and in the way attempted by the author. But the subject is so vast in its ramifications that really we doubt whether any one author can make an adequate summary of the information available. We are not able to pass a proper opinion on much of the matter in the book, more especially on the subjects more strictly belonging to municipal engineering, and but slightly related to other branches of engineering, and we feel that that is the aspect in which the author gives of his own particular experience, and therefore of his best. That aspect, we belive, he has dealt with in a valuable way, so that the book as a manual of municipal engineering practice fulfils its purpose, and deserves our commendation. But in the aspects of general constructional engineering practice, with which we deal, we are disappointed with the book. We would like to gloss over its discrepancies, if they could be considered unimportant, but the errors of omission and commission and the methods of approach and demonstration are really too numerous. The way in which the formulæ are derived is often not explained, and yet the book is for young students. The author quotes, apparently with approval, some remarks on "Standardisation of Engineering Formulæ." It is a pity he did not more often follow some general method himself, and especially adopt the Concrete Institute's notation. The formulæ for calculations put forward in the chapter on "Concrete-Steel" design are neither the generally accepted ones, nor are they improvements, for they often do not logically follow from the author's premises. We are often in doubt as to quite what he is trying to get at, and we certainly cannot follow his reasoning always, so that we are sure the elementary student would be in a hopeless tangle. Most of the matter refers to rectangular beams, whereas T-beams are of first importance. We hope that the author will soon have occasion in a further edition to put the information on this and other branches of the subject of theory of structures right. One of the most valuable features of the book is the large number of drawings of executed works included in it.



MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

The Colloid Theory of Cements.—The following is an abstract of a paper read before Section B of the British Association by Dr. C. H. Desch :

The theory of the setting of cements due to Le Chatelier, depending on the interlocking of crystals growing from neighbouring centres, fails to account for the great mechanical strength attained by cements. On the other hand, the late Prof. Michaelis attributed the setting to the formation of colloidal products. Microscopical examination fully confirms this view. The action of water on the alike crystals of the cement brings about hydrolysis of the aluminates and silicates present. The hydrated calcium aluminate formed during the initial set is chiefly crystalline, but the hydrated calcium metasilicate formed during the principal setting process, being extremely insoluble, separates as a colloidal gel. A portion of the lime set free crystallises, the remainder is at first in solution. The gradual hardening of the cement is due in the first place to the shrinkage and dessication of the gel, a part of the lime being absorbed at the same time. This absorption may continue for a long period, lime gradually penetrating further into the dessicated gel, increasing its hardness and strength.

The process may be followed by means of the microscope, especially when advantage is taken of the differential staining of colloids by dyes, such as safranin and patent blue. In the study of clinker, the difficulty hitherto found has been that of grinding sufficiently thin sections of so brittle a material. This may be avoided by treating the clinker in the same manner as a metallo-graphic specimen ; that is, by grinding and polishing one surface only, etching lightly with water or acid, and examining by vertical illumination. This method may also be applied to mortar after setting. The application of Michaëlis's theory throws an entirely new light on the process of setting, and gives an explanation of many points which were previously obscure.

The Disappearance of Rust from Steel Reinforcement.—It has been observed on several occasions during the destruction of reinforced-concrete work that steel rods which had been set in place in a rusty condition had become bright and practically free from rust. The fact has been repeatedly confirmed, and experiments on a small scale show that the removal of rust takes place for the most part during the period immediately after setting, when the concrete still contains much moisture. The chemical nature of the process is not very obvious, and when the matter was first discussed in 1909 in the pages of *Stahl und Eisen*, several hypotheses involving the presence of unlikely compounds were proposed. Recent experiments by Prof. Donath, of Vienna, show that, as suggested by the late Dr. Michaëlis, the lime set free during the setting of the cement is the active agent. Lime mortar is therefore capable of acting in the same way. The lime, while still in the moist, colloidal state, reacts with the combined ferric oxide, which is one of the constituents of iron rust, and a hydrated calcium ferrite is formed. It is true that some other constituents are not acted on, but the conversion of a part of the rust into a soluble form so loosens the texture of the mass that it becomes completely detached from the steel. Whilst the fact is not of great practical importance, as reinforcing rods should always be freed from adhering rust before setting in place, it affords further evidence of the complete immunity from rusting which is enjoyed by steel embedded in well-made concrete.

Sealing Canal Dykes with Concrete.—A method of sealing canal dykes against leakage, which has recently been successfully employed on European canals, consists, according to *Engineering Record*, in the insertion of a thin concrete cut-off wall in a narrow trench, or slot, prepared by driving and pulling a single row of timber sheet-piling progressively in short sections. It has been found practicable to conduct repairs by this procedure without drawing off the water in the canal prism. A brief description thereof is given in the *Zeitschrift* of the Austrian Engineers' and Architects' Society.

According to the method formerly customary, the canal is emptied and the bottom and slopes trimmed and paved in the locality of the leakage. This work is then covered as a protection against damage from contact with the bottoms of canal boats. The cost of such repairs is on some canals about 12s. 6d. per lineal ft. of canal repaired. Another plan is to excavate a trench in the middle of the towpath and to refill it with well-tamped earth, but this is generally possible only to depths up to about 5 ft. below the water surface, and requires shoring. If it is desired to go deeper, water makes the work laborious and expensive.

The method employing the thin concrete wall permits of reaching depths up to 8 ft. below the water surface, and has been followed at a cost of about 3s. 9d. per lineal ft. A shallow working trench is opened on the dyke, and wooden sheet piles are driven with tight joints down to firm material. The piles are about 10 in. wide, 7 in. thick at the top, and 5 in. at the bottom. They are pointed at one side so as to draw them together in driving, and are equipped with shoes. They are uniformly dimensioned and well made, so as to produce an even opening in the dyke. In driving, a pile with a centre point is first placed, and those with side points on either side of it. When a line of piles has thus been set, they are carefully drawn, one at a time, and the hole filled with concrete. The pile is first drawn 4 in. to 8 in. to loosen the hold of the surrounding material, and then is slowly raised, care being taken not to knock earth back into the hole. A steel funnel, shaped so as to enter the hole, protecting the sides and edges, and to rest against the adjoining wooden pile, is next inserted and filled with concrete mixed quite dry. As the concrete is tamped into place with a long-handled ram, the form is withdrawn. This process is repeated with the next pile, the sides of the hole and the face of the concrete being cleaned with an iron rod before inserting the steel guide for new concrete. The piles which are withdrawn are cleaned and moved ahead for re-use. In sandy and stony material, where the caving of the sides and flow of water present serious difficulties to the employment of this method, reinforced-concrete sheet piles are used, bonded into a solid wall by mortar.

Reinforced Concrete Work in Belgium.—It has been decided by the Road Surveying Department to construct a road bridge over the river Ourthe at Chênée, near Liége, and also a viaduct to cross the yards of the Vielle Montagne works. Both undertakings will be carried out in reinforced concrete.

The bridge will consist of a skew span at an angle of 8 degrees, with a normal length of 55 m. between abutments. On the down stream side stairs of 1.5 m. effective width will be provided. The treads will be built of ashlar stone. This staircase will give access to the left towing-path of the river. Both the bridge and the stairs are to be provided with ornamental parapets. The viaduct will consist of nine spans of 9 m. in length, supported on piers in front of those of the existing masonry viaduct. The bridge and the viaduct will give an effective width of about 7.5 m., of which 5 m. will be apportioned to the road, and the balance to two footpaths. There will be an embankment on either side to serve as approaches from the river. The retaining walls for the approaches are to be built either in masonry or in concrete, and are to be fitted with parapets.—*The Times*.

Cement in the Construction of Cowsheds.—In a paper on "The Construction of Cowsheds," read at the Royal Sanitary Institute's Congress in Belfast, Mr. J. H. Sutton, of Nottingham, says:

"The floors should consist of some impervious material, such as concrete and cement, or concrete and blue pavers laid in cement; I prefer the latter because they are so easily kept clean. They are impervious, and are fairly smooth on the face. It may be said that these materials are too costly for floor paving, but I would reply that it is the cheapest in the long run. I have seen such a floor that had been used for forty years and had not cost a penny for repairs during that period. If soft brick and stone paving is used, it is always out of repair, and lends itself more readily to the absorption of liquid. . . .

"The inside walls in rear and at the ends should be composed of some impervious material to a height of 4 ft. 6 in., because this portion requires constant cleansing. Brown or white-glazed bricks are suitable, but surface rendering in cement is to be recommended because of its cheapness and adaptability. Cement is impervious, is easily cleansed, and if limewashed the same as the upper portion of the walls, any accumulation of dirt or dung is easily detected."

Effect of Lightning on Concrete.—The effect of lightning on concrete, which has long been a matter of dispute, has been observed by a leading member of the American Society of Civil Engineers, who has a reinforced-concrete water tank on his country estate. This was struck by lightning, which caused no injury, but changed the texture of the concrete in places from granular to vitreous. The tank was heavily reinforced.

Concrete v. Stone.—Recently the members of the Leeds Corporation paid a visit to the new waterworks in the neighbourhood of Masham, where Messrs. H. Arnold & Son, contractors, of Doncaster, are now carrying out the new Leighton Reservoir, which, when completed, will hold as much as 1,136,000,000 gals., and during the inspection of the works it was pointed out the great saving that had been attained by substituting concrete for stone work in one of the trenches which are to conduct the water into the reservoir. In one alone, which will be two miles long, there has been some 1,500 ft. lineal constructed, and by the substitution of concrete work for stone, it is estimated that there has been a saving of somewhere between £8,000 and £9,000. It is in such actual practical instances as these, when it is seen how much greater advantages can be derived from the adoption of concrete work for stone work, and more especially in the reinforced concrete of the present day, which are making the latter become more and more popular for the entire construction of reservoirs.

Amended By-laws.—The Harrogate Corporation have considered and amended their Building By-laws, to enable buildings to be erected in reinforced concrete, and have applied to the Local Government Board for their approval of the same.

Conservative Club, Oldham.—A new Conservative club is being erected in Oldham from the designs of Mr. C. T. Taylor, A.R.I.B.A., by Mr. J. Bewley, contractor, who is carrying out all the reinforced concrete work on the Lewis Construction Company's system.

Central Stores, York.—Mr. W. Bell, the architect to the North Eastern Railway Co., has invited tenders on the Hennebique system of reinforced concrete for new central stores at York.

Residential Flats, Leeds—Messrs. J. Wood & Sons, contractors, of Hyde Park, Leeds, are erecting a block of residential flats at Headingley, a residential suburb of the city, in which they purpose carrying all the floors out in reinforced concrete.

Warehouse, Liverpool.—An extensive new wool warehouse is to be erected in Liverpool for the Mersey Docks and Harbour Board, having all the floors and stanchions supporting same constructed of reinforced concrete. The contract for this has been let to Messrs. Kirk & Knight, contractors, of Sleaford.

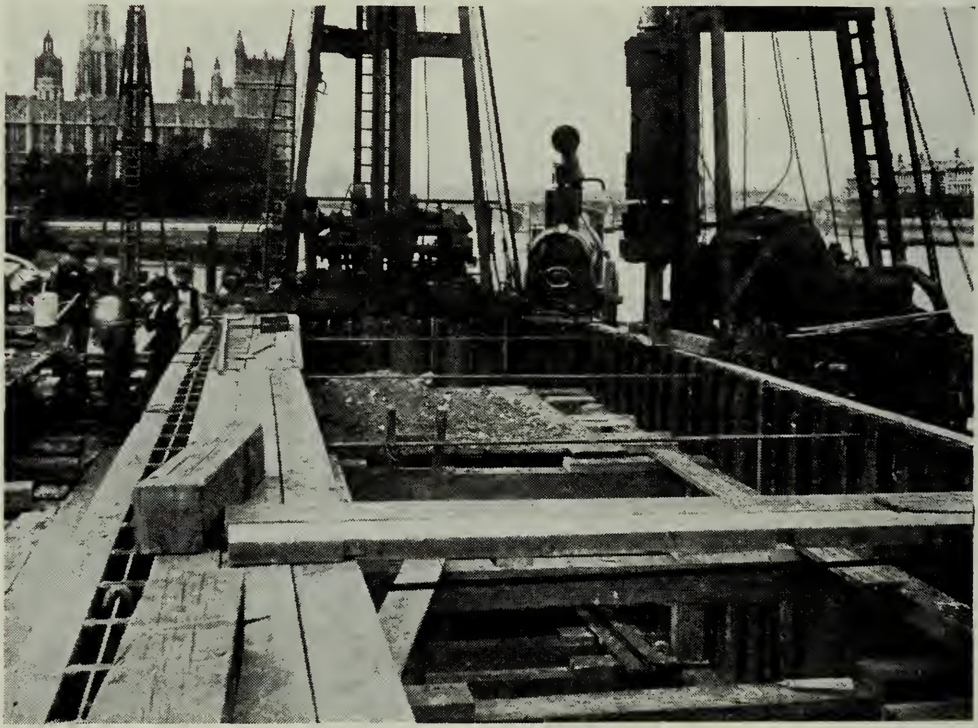
New Baths, Withington.—The city architect of Manchester has recently been obtaining tenders for new swimming baths at Withington, which are to be erected in reinforced concrete.

Electricity Works, Hull.—The Hull Corporation are erecting new electricity works in reinforced concrete from their city engineer's own designs, which are being carried out by Mr. T. J. Levitt, contractor, of Hull.

Proposed Sewage Tanks in Reinforced Concrete.—The Chesterfield Rural District Council contemplate at an early date applying for permission to borrow from the Local Government Board for the carrying out of sewage tanks in reinforced concrete.

UNIVERSAL JOIST STEEL SHEET PILING

As used by the British and Colonial Governments, French Government, London County Council, Mersey Dock and Harbour Board, Immingham Dock, Hull Joint Dock, etc., etc.



NOTE HOW EASILY DAM WAS CLOSED UP.
NO SPECIAL PILES REQUIRED TO EFFECT THIS.

Illustration shows our 15 in. × 43 lb. piling in use on the new Embankment Wall at Millbank, Westminster. The dam shown is 210 ft. long × 13 feet wide. The piles at front are 46 ft. 6 in. long, and at back 41 ft. These were driven through river ballast and sand into London clay. Same will be withdrawn and used three times.

THE BRITISH STEEL PILING CO.

DOCK HOUSE, BILLITER STREET,
LONDON, E.C.

Telephones—1414 Avenue
1414 Central

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"Gramercy, London."

CORRESPONDENCE.

Dear Sir, — We read with much interest your editorial article dealing with the state of the reinforced concrete trade in the country.

We must agree with many of your remarks, but consider that the real cause of the depression at present existing is almost wholly due to the indiscriminate cutting of prices, which in many cases is due to real ignorance of the cost of the work.

We are continually having cases brought to our notice of work, particularly centering, which is priced 20 per cent. to 35 per cent. below actual prime cost. You will in no case find a firm who have carried out any considerable amount of reinforced concrete work submitting such tenders. Such cutting in price does not conduce to the best practice, and seriously threatens the maintenance of the standard of workmanship in this country, which fortunately up to the present has been high, and which it is to the ultimate interests of everyone to maintain.

We cannot agree with your remarks that there is not room for firms to devote themselves entirely to reinforced concrete construction—*i.e.*, the actual erection. The erection, to our mind, requires much more attention, special experience, and a real understanding of the design than any general contracting firm can afford to give it. There are any number of good builders and contractors in this country who have badly burned their fingers in undertaking reinforced concrete work, as they have found that it cannot be handled and made to pay by those ordinary methods of contracting which in general work are satisfactory. Our opinion is that the industry is at present in a transition stage, and is gradually getting into stronger hands, and will eventually, like constructional steelwork, be confined to recognised firms of good standing and experience.

About three years ago there was a pronounced boom in reinforced concrete. Any number of firms, thinking there was a fortune to be made in it, started away with insufficient capital, no experience, and a lack of technical knowledge. Prices came down with a rush, thousands of pounds were spent in getting out schemes, 50 per cent. of which should never have been contemplated in concrete, and naturally money was lost all round, and many of the firms have either had to retire from the field or close up altogether. Exactly the same thing happened in France, but eventually the business settled down into a satisfactory state, and efficient experienced firms are now handling the erection of reinforced concrete as a separate business, apart from general contracting. Our own experience is that, although we have always designed and tendered on a sound basis, and asked for a fair price for proper workmanship, we have never known what it is to be really slack, and at the present time our order book is better stocked than it has ever been. This, too, we think, is the experience of a goodly number of other firms who, like ourselves, made a study of reinforced concrete many years ago.

Yours faithfully,
For D. G. Somerville & Co.,
D. G. Somerville.

The Editor, Concrete and Constructional Engineering.

ENQUIRY.

W. H. B., Newcastle, New South Wales, writes :

" I should be glad if you would kindly give me, through your paper, proportions of material for agricultural drain tiles or pipes, to make a porous pipe similar to clay pipes. I am near the coast, and there is plenty of sea sand, and possibly very soft sandstone (in a state of decomposition)."

Reply.—We would suggest that you make tests with various mixtures of concrete. We can only offer a few general suggestions, not having the materials submitted to us. We would not favour the decomposed sandstone for aggregate. You might be able to make a satisfactory pipe with gravel graded from ½ in. to ¼ in. mixed with Portland cement in the proportion 4 or 5 to 1 without sand. Also sand and cement alone proportioned 5 to 1 might prove satisfactory, but we prefer the gravel.

TRADE NOTICES, CATALOGUES, ETC.

Indented Bar Bulletin.—The seventeenth issue of the bulletin published by the Indented Bar & Concrete Engineering Co., Ltd., contains some very interesting illustrations of work carried out in reinforced concrete on their system, notably among which are those of the Abbassia Barracks, Cairo, in which reinforced-concrete floors have been used throughout. These barracks comprise altogether a series of twenty buildings, several of them of very considerable extent. Other illustrations in the bulletin represent a mill at Truro, joinery works, Letchworth, and a water tower at Middlesbrough, in all of which Indented bars formed the reinforcement.

A copy of this bulletin will be sent to any of our readers free of charge on application to the Indented Bar & Concrete Engineering Co., Ltd., of Queen Anne's Chambers, London, S.W.

Ransome Mixers used at the Royal Liver Building.—In our October number we gave an account of the Royal Liver Building, Liverpool, and we are now informed by the Ransome ver Mehr Machinery Co. that the contractors used a No. 2 Ransome mixer in the construction of this building. One machine carried out the whole work, cost practically nothing for repairs, and gave entire satisfaction.

Power's & Dean, Ransome's Limited.—We have been informed that Mr. Geo. H, Gascoigne has been appointed manager of the reinforced concrete department of the above-named firm.

The offices of the company are at 5 Mark Lane, and they are contractors for every description of reinforced concrete work.

CONTRACTS.

Extensive Sanitary Works for the Town of Guayaquil, Ecuador.—We have been informed that, with the approval of Congress, the Government of Ecuador has signed a contract with the representative of Monsieur Edmond Coignet, of Paris, authorising the issue of a loan of 50,000,000 francs (£2,000,000) for the purpose of obtaining the required funds for the execution of certain sanitary works in the town of Guayaquil, works which this engineer has undertaken to carry out for the Guayaquil Municipal Council and the Sewage Commission. We understand that these works will include a large amount of reinforced concrete.

The contract was obtained by Monsieur Coignet in the face of a good deal of opposition from United States contractors.

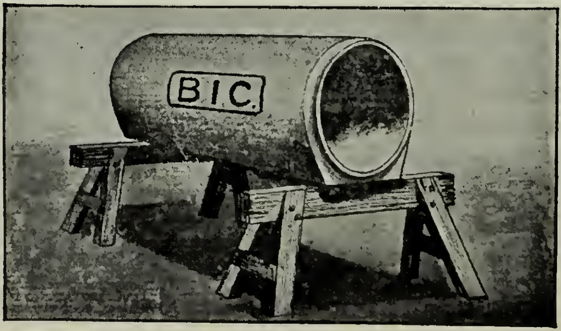
"BIC" BRITISH "BIC"
IMPROVED CONSTRUCTION CO., LD.

TELEPHONE: 4067 VICTORIA. TELEGRAMS: "BICONCRETE, LONDON."

47 VICTORIA STREET, WESTMINSTER.

Flat-based Concrete Pipes

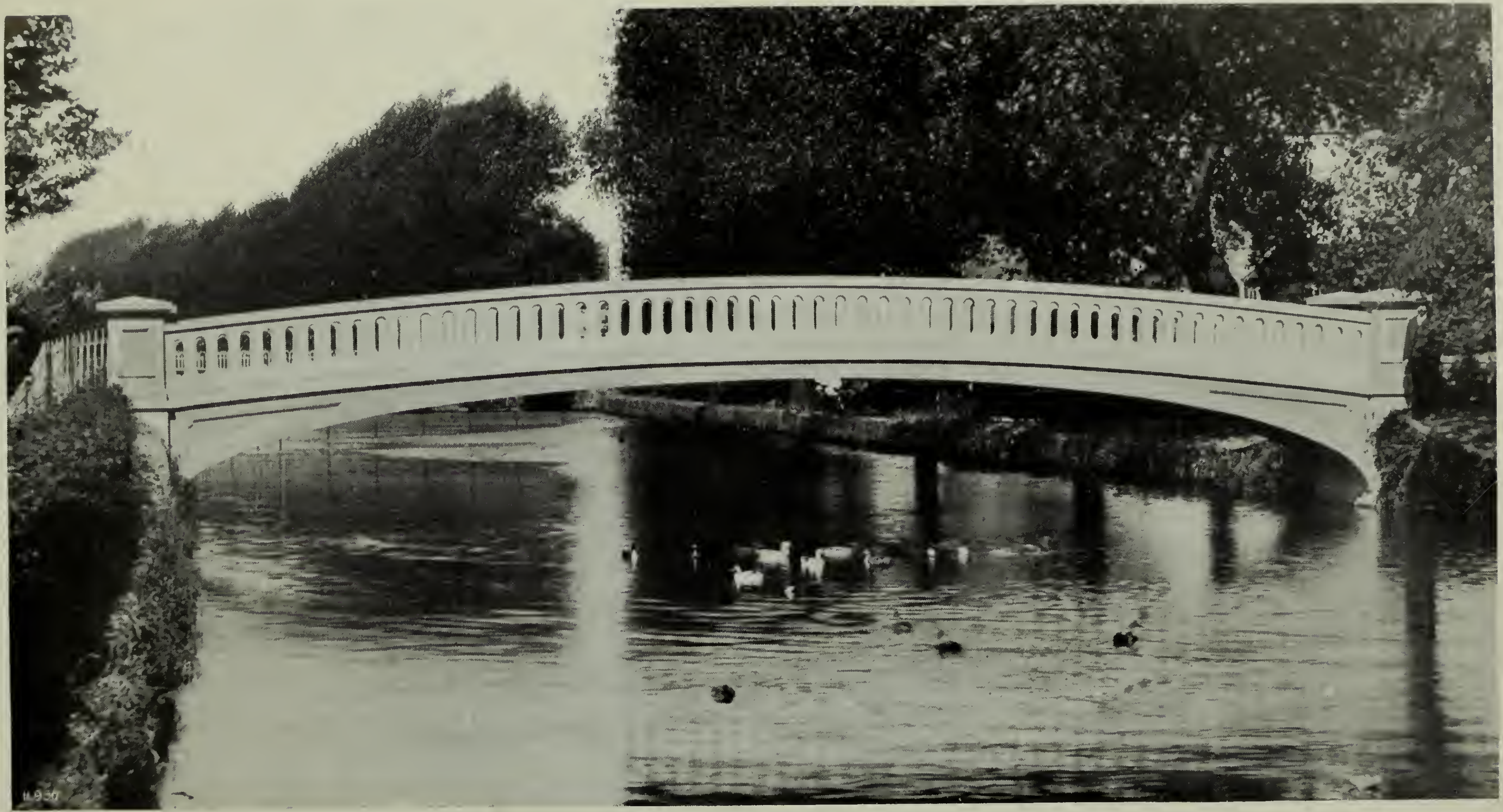
Three feet long to Nine feet long.



Breeze Partitions
Reinforced Sleepers
Telegraph Poles

Porous Pipes
Concrete Beams
Hollow Floors

SPECIALITY:—INVENTORS' DESIGNS CARRIED OUT TO ORDER.



View of Finished Structure. (*See description on page 958.*)
REINFORCED CONCRETE FOOTBRIDGE OVER THE RIVER SOWE, STAFFORD.

CONCRETE
AND
CONSTRUCTIONAL ENGINEERING

Volume VI. No. 12. LONDON, DECEMBER, 1911.

EDITORIAL NOTES.

THE CONCRETE INSTITUTE.

In the current issue we are giving prominence to Sir Henry Tanner's interesting presidential address to the members of the Concrete Institute.

In many directions this address is eminently instructive, and in matters relating to the general position of concrete and reinforced concrete in Great Britain the views expressed, coming from such an authoritative source, should not only be carefully mastered by our readers, but should be acted upon promptly. This particularly applies to the President's remarks on legislation and on tenders.

The address naturally also covers matters relating to the position of the Concrete Institute as an entity and the fact that since certain changes were made during the winter of 1909-1910 that body has in several respects been marking time rather than enjoying that continuous period of energetic development and growth which was a happy feature of its early days.

In this issue we will deal with that part of the address that relates to the Concrete Institute *per se,* for we believe that the development of concrete and reinforced concrete in England and throughout the Empire, together with the technical standing of those professionally and industrially concerned in applying these materials, are to a very large extent dependent on the prestige of the Concrete Institute as their representative body. To tamper with the primary objects of the Concrete Institute, to change the fundamental features of its constitution, or to venture to change its name, would be not only fatal to the Institute, but at the same time give concrete and reinforced concrete the greatest set-back it has so far experienced anywhere in the world.

The knowledge and the development of the uses of iron and steel, as furthered by the Iron and Steel Institute, are practically subsidiary to the greater subject of civil engineering as defined in the beautifully worded charter of the Institution of Civil Engineers. Concrete is in the identical relationship to the subject of engineering in its widest sense. Standing as an entity, the Iron and Steel Institute embraces among its membership the civil, mechanical and structural engineer, the scientist and the chemist, the industrial leader and manager concerned, and similarly the Concrete Institute represents those varied interests. To make the Concrete Institute in any way subservient to any specific branch of engineering, such as structural engineering, to any special industry such as that of reinforced concrete, or to any special science as that of the cement chemist, would be as if the Iron and Steel Institute were to make its interests subsidiary to the mechanical engineer, to the metallurgical profession, or to the ironmasters. Just as the Iron and Steel Institute would become a fiasco if it blundered on the lines indicated, so would the Concrete Institute promptly lose its *raison d'être* and prestige in such a case.

THE MISTAKE OF TAMPERING WITH ITS OBJECTS OR TITLE.

That some such change is actually under consideration in the Concrete Institute is apparent from the presidential address, and we regret that such a matter should have been under contemplation even for one instant. Further, we are somewhat at a loss to understand why this idea, which takes a prominent place in the presidential address, should have been brought forward at all at this stage. It cannot be in the interests of the development of concrete and reinforced concrete—quite the reverse. It would be idle to contend that the investigation of those two materials does not afford sufficient scope for a well-managed society, be it the Concrete Institute or a new one with identical objects, for at least another quarter of a century. We know of no other subject in civil engineering requiring more close attention from all concerned, more detailed research or discussion. There is only one reason that we can imagine for any change in the constitution and objects of the Institute. It must be a desire to improve the internal economy of the Institute—*i.e.,* some desire to improve its revenue. In other words, the idea of a change of constitution, as suggested, has a monetary basis and is simply a makeshift, having nothing whatever to do with the great purposes for which the Institute was incorporated and the great technical duties it ought to fulfil.

POSSIBLE INCREASE OF REVENUE.

We have no doubt that there is some tangible reason for this desire for a great increase of revenue. The Institute has, according to the presidential address, found that during the last two years, when the energetic management of earlier days was not being carried on, there was a stoppage in the flow of new members; there have been resignations for some reason or other, no funds from fresh subscribers or donors have been forthcoming; there has been little or no sale of the Institute's *Transactions* to non-members. Administrative and other changes have cost money, and the Institute lacks money. But surely all this, if actually the case, does not involve changes of constitution or name. At the most it means opening the doors of the Institute to architects and surveyors, structural engineers, teachers of building construction, district and borough surveyors, cement chemists and others who have not, so far, been specifically invited to join as the civil engineers originally were, but who should certainly all be interested in the Institute's work. There are many means for increasing the membership if energetically and, above all, tactfully applied, whilst duly guarding the doors against the unsuitable and insufficiently educated.

Further, why not have an entrance fee and eventually raise the annual subscription for future members? Why not encourage special subscriptions for its library, for literary and research work, obtain a sale for the excellent *Transactions,* have paying lecture schemes, and even paying diploma examinations on special subjects? Then the students' scheme should be developed and produce a substantial revenue. Altogether the ways of increasing the Institute's funds are numerous without tampering with the constitution of the name of that body, which in any case would mean disaster.

THE IRRESPONSIBLE MANAGEMENT OF GIANT "BOARDS."

The management, as we have already ventured to hint for some little time, has not been as effective of late as it was in its earlier days. We fully realise that in the beginning, when the management rested very much with a small executive of three, exercising somewhat autocratic powers, the methods of obtaining the results, however beneficial, did not accord with the modern ideas that a multitude of heads spells wisdom. The whole modern tendency in all societies, national, political or technical, is towards the more republican method of management by large committees of talkers rather than workers. The Institute is now managed in its veriest detail by a Council of some thirty members, amongst whom the interest in their work varies materially, and probably rarely involves an attendance of half their number, or, say, a consecutive attendance at any three meetings by an identical ten. Only in one instance—if we are rightly informed—during the last two years has the new form of management been replaced by effective personal management—namely, as referred to by one of the speakers on the address, when Sir Henry Tanner took the reins personally in his hands for the organisation and conduct of the Institute's first annual dinner. Even in that case there had to be nominally a dinner committee, but fortunately that committee left the President a free hand.

RESPONSIBILITY AND THE INDIVIDUAL.

We believe that there are already signs that the Council itself realises that its republican methods are leading in a wrong direction, and that small special working committees, and the delegation of specific work to the individuals most suited, may again be favoured. We would strongly urge upon the Institute's Council that it should again delegate, as in its earlier days, certain specific functions to small sub-committees not exceeding three or five, each member of which is personally interested in the subject dealt with by the sub-committee in question and is prepared to deal with it in that energetic and prompt manner with which he would deal with his own as distinct from corporate affairs. That method is the only possible one if successful work is to be obtained.

If the General Meetings are to be made more popular let certain individuals be responsible for the meetings, their management, their conduct in every way. If it be a question of the publications, let the same method prevail. But to imagine that the Institute's meetings will be well attended, will be attractive or in any way popular when it is nobody's business to look after them properly, when the selection of the locale of the meetings allows of the President's address being accompanied by tramway noises, and its Summer Meeting by hammering, is farcical. To imagine that members of the Institute will be satisfied when their *Transactions* appear at the erratic and delayed intervals that they now do, because it is nobody's business to see that they are got out promptly, is absurd.

We say all this in no carping spirit. We simply wish to indicate what has come to our notice in innumerable letters from members and ex-members of the Institute, and we only give indications with a view to suggesting that the Institute should promptly put its house in order with regard to the management before it takes up the makeshift problem of changing its name, objects and constitution.

GENERALLY.

If structural engineers wish to have a society of their own, let them have one by all means; if three or four individual members of the Council are particularly anxious that this should be the case, let them turn their energies to the formation of an Institute of Structural Engineers; but let the members as a whole, who joined owing to their interest in concrete and reinforced concrete, realise that in the meantime their interests are side-tracked to make room for the discussion of administrative " aerial castles." Time is wasted which would be far better applied to really constructive work in the advancement of research and technical education.

At the same time, it should be clearly understood that if the Concrete Institute desires to use the nucleus of its large membership for the purpose of making a structural engineering institution, they will immediately lose the majority of their present members, and that there is also very little doubt that but very short time would elapse before some other corporation would have to be formed to satisfy the requirements of those specifically fathering the science and industry concerned, as the interests of concrete and its constituents are far too great to be made subsidiary to any second-rate or minor technical society sailing under the flag of " Structural Engineering."

STRUCTURAL ENGINEERS.

As a result of Sir Henry Tanner's address we have received numerous inquiries for a definition of " Structural Engineers," and though we have looked up various dictionaries and inquired from authoritative sources, we are afraid that the term does not appear to be recognised as a professional description, and is thus certainly not as desirable a one from the professional and scientific points of view as some apparently think.

Generally speaking, a structural engineer, as recognised by building owners and employers, as also by the members of the engineering and architectural professions, is an individual or firm engaged in contracting for steel structural work of all descriptions above ground and, in exceptional cases, underground, who may or may not do a certain amount of designing in connection with tenders or the execution of contracts.

To speak of a structural engineer in common parlance means referring to a contractor in that speciality.

A few unsuccessful civil engineers or would-be members of the Institution of Civil Engineers who have failed in their examinations, and a few engineering employees of structural contracting firms, like to call themselves structural engineers, as also some of the minor employees in our public bodies, who cannot be classed as either architects, civil engineers, surveyors, or clerks.

No self-respecting civil engineer who is a consulting—*i.e.*, professional—engineer would either colloquially or in a court of law describe himself as a structural engineer, and thus we feel that, apart from any points raised in the above leading article dealing with the Concrete Institute, and the danger of its tampering with its name, the mere fact of adopting a title in which the term structural engineer figures would, *ipso facto,* give the Institute to which it is applied a far lesser standing than it enjoys at present.

LONDON COUNTY COUNCIL'S REGULATIONS FOR REINFORCED CONCRETE.

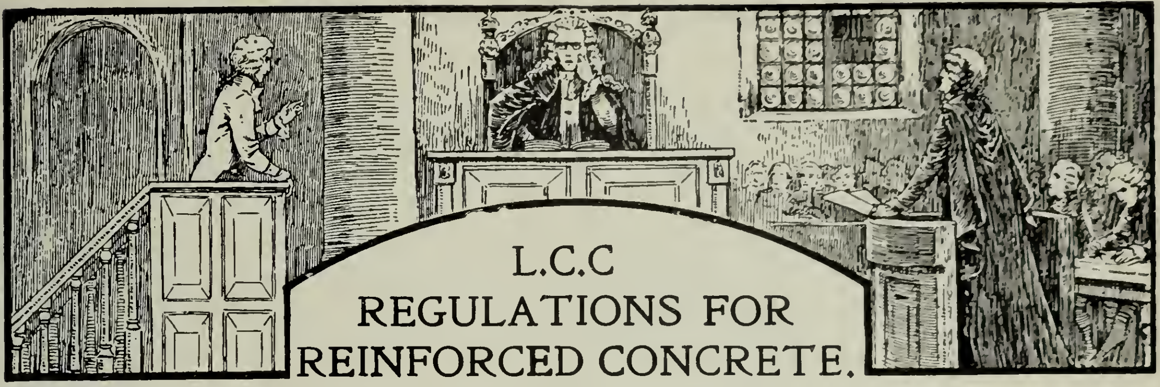
On November 13th, 1911, almost two and a half years after the passing of the London County Council General Powers Act of 1909, which gave that body powers to issue regulations on reinforced concrete, the Building Act Committee of the London County Council has definitely reported its requirements to the plenum of the Council, and the Council of November 21st, 1911, has decided to go to the Local Government Board and ask for the confirmation of the rules it suggests.

We are thus practically within sight of rules on reinforced concrete being adopted for the Metropolis, and, with a certain amount of good fortune, three years will not have quite gone by before the much-discussed and long-needed code is put into force. If we add that the matter was under consideration for quite two years before powers were granted by Parliament, we find that this simple piece of administrative work relating to reinforced concrete has taken the combined forces of the House of Commons, the House of Lords, the London County Council, numerous special Committees, and at least half a dozen of our great Institutions a full five years to obtain what in nearly every other country could be obtained, with due consideration and full efficiency, in about a period of something like six months. No wonder reinforced concrete construction is handicapped in the Metropolis if these are the methods—if methods they can be called—to which it is subjected.

To put matters quite plainly, five years have been wasted. Large sums of money have had to be thrown away unnecessarily by building employers—and for what? Simply to pander to an inane conservatism against new building methods.

We have pleasure in giving in this issue the rules as defined by the Building Act Committee and adopted by the London County Council, together with the short preamble submitted by the Building Act Committee. From this preamble it will be observed that certain Institutions named in the Act—namely, the Surveyors' Institution, the Institution of Civil Engineers, the Royal Institute of British Architects, and the Concrete Institute—who have to be consulted by the Local Government Board before the rules are approved, have been previously approached in the matter of these regulations, and similarly a number of other Institutions have been invited to pass opinions on the rules in question. The outcome is a set of regulations which are a fair compromise of the various views indicated, excepting, however, those of the Royal Institute of British Architects, who appear to have been adverse to any regulations whatsoever.

It is not our intention at present to deal at length with the rules themselves, and we only publish them now as indicating what the London County Council consider desirable, and what a good many reasonable professional men think advantageous. We will enter into a discussion of some of the details of the regulations at a later stage, but, generally speaking, we would like to congratulate Mr. W. E. Riley, the Superintending Architect, for the manner in which he has prepared these rules, regardless of the methods of opposition to which he was subjected both in Parliament and at a later stage, and if we do not quite see eye to eye with him on some small technical matters, we would, however, like to say that on the broad principles set out in these rules we, as representing a large number of those interested in the science of building construction, in the application of concrete and reinforced concrete and the users of such materials, welcome the new regulations as being necessary and essential to the well-being and safety of the Metropolis and of great economic value to building owners throughout the County of London.



L.C.C REGULATIONS FOR REINFORCED CONCRETE.

At a meeting of the London County Council, held on the 21st November, 1911, Mr. Edward White, J.P. (Chairman), presiding, the following report of the Building Acts Committee as to regulations respecting reinforced concrete buildings under the London County Council (General Powers) Act, 1909, was submitted to the Council and approved by them, and the Council has decided to send the regulations to the Local Government Board for confirmation.—ED.

REPORT OF THE BUILDING ACTS COMMITTEE.

Regulations with respect to the construction of buildings wholly or partly of reinforced concrete.

1.—WITH regard to the authority conferred on the Council by section 23 of the London County Council (General Powers) Act, 1909, to make regulations with respect to the construction of buildings wholly or partly of reinforced concrete, we have prepared draft regulations.

By section 23 (4) of the Act, the Council is required to give to the Surveyors' Institution, the Institution of Civil Engineers, the Royal Institute of British Architects, and the Concrete Institute notice of its intention to apply to the Local Government Board for allowance of any regulations made under this section, and with a view to the avoidance of material alterations in the regulations by the Local Government Board, the suggestions of these authorities on the draft regulations have been invited, and, in a large majority of instances, incorporated therein. If the Council approves the regulations, it will be necessary for them to be confirmed at a subsequent meeting. The Board should be asked to fix a date for the coming into operation of the regulations. We recommend—

(*a*) That, pursuant to the provisions of section 23 of the London County Council (General Powers) Act, 1909, regulations with respect to the construction of buildings wholly or partly of reinforced concrete be made as follows—

(*b*) That, on confirmation of the regulations referred to in the foregoing resolution (*a*), the necessary steps be taken to obtain the sanction of the Local Government Board thereto, and that the Board be asked to fix a date for the coming into force of the regulations.

(*c*) That, on confirmation of the regulations referred to in the foregoing resolution (*a*), notice be given to the Surveyors' Institution, the Institution of Civil Engineers, the Royal Institute of British Architects, and the Concrete Institute of the Council's intention to apply to the Local Government Board for allowance of the regulations referred to in the foregoing resolution (*a*).

Regulations referred to in paragraph No. 1 (a) of the foregoing report—

Regulations with respect to the construction of buildings wholly or partly of reinforced concrete and with respect to the use and composition of reinforced concrete in such construction.

Whereas under the provisions of section 23 of the London County Council (General Powers) Act, 1909, the London County Council (therein and hereinafter referred to as "the Council") have power to make regulations with respect to the construction of buildings wholly or partly of reinforced concrete and with respect to the use and composition of reinforced concrete in such construction.

Now therefore in pursuance of the powers conferred upon the Council by the said section the Council do hereby make the following regulations:

PART I.

GENERAL.

1.—Reinforced concrete the subject of these regulations shall be concrete reinforced by metal so combined that the metal will

(*a*) be sufficient to take up all the direct tensile stresses;
(*b*) assist in the resistance to shear;
(*c*) assist in the resistance to compression where necessary;

and where the term "reinforced concrete" is hereafter used in these regulations it shall mean concrete reinforced as aforesaid.

2.—The skeleton framework of reinforced concrete of a building together with the party wall or party walls (if any) upon which such framework bears shall be capable of safely and independently sustaining the whole dead load and the superimposed load bearing upon such framework and party wall or party walls.

3.—All floors and staircases (together with their enclosing walls) shall be constructed throughout of fire-resisting materials and be carried upon supports of fire-resisting materials.

4.—In the case of the erection of a new building of reinforced concrete or the making of any addition or alteration or the carrying out of other work under the provisions of these regulations the notice required to be served on the district surveyor under section 145 of the London Building Act, 1894, shall be accompanied (*a*) in the case of a new building by plans and sections of sufficient detail to show the construction thereof, together with a copy of the calculations of the loads and stresses to be provided for and particulars of the materials to be used; and should such plans, sections, calculations or particulars be, in the opinion of the district surveyor, not in sufficient detail, the person depositing the same shall furnish the district surveyor with such further plans, sections, calculations or particulars as he may reasonably require, and (*b*) in the case of an alteration or addition or other work as aforesaid by such plans, sections, calculations and particulars as the district surveyor may reasonably require.

5.—Nothing in these regulations shall be deemed to authorise the construction of buildings of reinforced concrete in which the loads and stresses are not transmitted through each storey to the foundations by a skeleton framework of reinforced concrete or partly by a skeleton framework of reinforced concrete and partly by a party wall or party walls.

PART II.

DATA.

Floor and roof loads.

6.—The dead load of a building shall consist of the actual weight of walls, floors, roofs, partitions and all other permanent construction comprised in such building.

7.—The superimposed load in respect of a building shall consist of all loads other than the dead load.

8.—For the purpose of calculating the loads on foundations, pillars, piers, walls, framework, beams and other constructions carrying loads in buildings, the superimposed load on each floor and on the roof shall be estimated as equivalent to the following dead load :—

9.—

For a floor intended to be used wholly or principally for the purpose of	Equivalent dead load in lb. per sq. ft.
Artisan's dwelling	70
Domestic purpose	70
Human habitation	70
Private dwelling-house ...	70
Asylum wards	84
Common lodging - house bedrooms	84
Hospital wards	84
Hotel bedrooms	84
Workhouse wards	84
Counting houses	100
Offices	100
Other similar purposes ...	100

For a floor intended to be used wholly or principally for the purpose of	Equivalent dead load in lb. per sq. ft.
Art galleries	112
Chapels	112
Churches	112
Class rooms	112
Concert rooms	112
Lecture rooms	112
Library reading rooms ...	112
Meeting rooms	112
Music halls	112
Public assembly	112
Retail shops	112
Theatres	112
Workshops	112
Ball rooms	150
Drill rooms	150
Similar floors subject to vibration	150
Book stores at libraries ...	224
Museums	224
Warehouses	224

10.—In every building of the warehouse class a notice shall be permanently exhibited in a conspicuous place on each storey of such building stating the maximum superimposed load per square foot which may be carried on any part of the floor of such storey.

11.—For a roof the plane of which inclines upwards at a greater angle than twenty degrees with the horizontal, the superimposed load, which shall for this purpose be deemed to include wind pressure and weight of snow and ice, shall be estimated at twenty-eight pounds per square foot of sloping surface normal to such sloping surface on either side of such roof.

12.—For all other roofs the superimposed load shall be estimated at fifty-six pounds per square foot measured on a horizontal plane.

13.—Provided that if the superimposed load on any floor or roof is to exceed that hereinbefore specified for such floor or roof such greater load shall be provided for.

14.—Provided also that in the case of any floor intended to be used for a purpose for which a superimposed load is not specified in these regulations, the superimposed load to be carried on such floor shall be provided for.

15.—For the purpose of calculating the total load to be carried on foundations, pillars and walls in buildings of more than two storeys in height, the superimposed loads for the roof and topmost storey shall be calculated in full, but for the lower storeys a reduction of the superimposed loads shall be allowed as follows :

16.—For the storey next below the topmost storey a reduction of ten per cent. of the calculated superimposed load shall be allowed ; for the next storey twenty per cent. ; and so on by increments of ten per cent. per storey till the reduction amounts to fifty per cent. It shall be taken at fifty per cent. for all floors below.

17.—No such reduction as aforesaid shall be allowed in the case of a building of the warehouse class.

Wind pressure.

18A.—All buildings shall be so designed as to resist safely a wind pressure in any horizontal direction of not less than twenty pounds per square foot of the whole projected surface normal to the direction of the wind.

18B.—All structures or attachments whatsoever in connection with a building, including towers or other parts which extend above the roof flat or gutter adjoining thereto, shall be so designed as to resist safely a wind pressure in any horizontal direction of not less than forty pounds per square foot of the whole projected surface normal to the direction of the wind.

Weights.

19.—In calculating the safe load on beams and floor slabs allowance shall be made for the weight of the beam or floor slab itself.

20.—For the purposes of calculation, the weight of reinforced concrete shall be taken at 150 pounds per cubic foot.

Ratio of span to depth of a beam.

21.—For the purpose of determining the ratio of span to depth of a beam, the effective depth of the beam shall be taken.

22.—The effective depth is to be measured from the compressed edge of the constructional concrete to the common centre of gravity of the tensile reinforcement.

23.—The span of a beam shall not exceed twenty-four times the effective depth of the beam unless the calculated deflection of such beam is less than one six-hundredth part of the span.

Bending moments.

24.—For the purpose of ascertaining the bending moments the effective span shall be taken.

25.—In the case of non-continuous beams, the effective span shall be taken as the distance between the main vertical sides of the piers, pillars or walls, plus the depth of the beam at the supports, or the span between the centres of the necessary bearing surfaces, whichever may be the lesser.

26.—In the case of continuous beams, the effective span shall be taken as the distance between the centres of the supporting beams, piers, pillars or walls.

27A.—Bending moment at the fixed end of a cantilever with a single concentrated load at the free end—$B = Wl$ where W = weight. l = length of effective span.

27B.—Bending moment at the fixed end of a cantilever with the load uniformly distributed—$B = \frac{Wl}{2}$

27C.—Bending moment at the centre of a beam with both ends freely supported and a single concentrated load at the centre—$B = \frac{Wl}{4}$

27D.—Bending moment at the centre of a beam with the ends freely supported and the load uniformly distributed—$B = \frac{Wl}{8}$

27E.—Bending moment at the supports and at the centre of a beam with both ends fixed and a single concentrated load at the centre—$B = \frac{Wl}{8}$

27F.—Bending moment at the fixed end of a beam with one end fixed and one end supported and the load uniformly distributed—$B = \frac{Wl}{8}$

27G.—Bending moment throughout the middle half of the span of a beam with one end fixed and one end freely supported and the load uniformly distributed—$B = \frac{Wl}{10}$

27H.—Bending moment at the ends of a beam with both ends fixed and the load uniformly distributed—$B_e = \frac{Wl}{12}$

27I.—Bending moment at the centre of a beam with both ends fixed and the load uniformly distributed—$B_c = \frac{Wl}{12}$

28.—The effective span of slabs shall be taken as the clear span plus the thickness of the slab.

29A.—Bending moment across the centre of a square slab supported on four edges and reinforced in two directions at right angles to each other with load uniformly distributed— $B = \frac{Wl}{16}$

29B.—Bending moment along the edges of a square slab fixed along four edges and reinforced in two directions at right angles to each other with reinforcements bent up over the supports, the load being uniformly distributed— $B = \frac{Wl}{24}$

29C.—When the length of a slab exceeds twice its breadth no allowance shall be made for support in the direction of the length of such slab.

29D.—For other ratios of length to breadth, the bending moments shall be found by the following formulas—

W = Weight on slab (total distributed weight, including its own weight).
b = *breadth* of slab.
l = *length* of slab.

B = Bending moment at any given cross-section.	Condition of supports.	B for shorter span.	B for longer span.
B at *centre* of span = B_c	Free	$\frac{Wb}{8} \cdot \frac{1}{1+\left(\frac{b}{l}\right)^4}$	$\frac{Wl}{8} \cdot \frac{1}{1+\left(\frac{l}{b}\right)^4}$
B at *end* of span = B_e	Fixed	$\frac{Wb}{12} \cdot \frac{1}{1+\left(\frac{b}{l}\right)^4}$	$\frac{Wl}{12} \cdot \frac{1}{1+\left(\frac{l}{b}\right)^4}$
B at *centre* of span = B_c	Fixed	$\frac{Wb}{24} \cdot \frac{1}{1+\left(\frac{b}{l}\right)^4}$	$\frac{Wl}{24} \cdot \frac{1}{1+\left(\frac{l}{b}\right)^4}$

30.—The spacing of the reinforcement in slabs under a uniform distributed load may be gradually increased from the middle third of the slab towards the outer edges of the slab provided—

(*a*) That the spacing at the outer edges be not greater than three times the spacing at the centre of the slab;

(*b*) That the bars or strands of the reinforcement be of uniform diameter or thickness throughout the cross-section of the slab.

31.—End spans of a series of continuous beams or slabs shall only be considered as fixed at the extreme ends when adequate provision is made for taking up the stresses which would be induced in the beam or slab and its supports.

32.—For every condition of loading not herein specified, the bending moment and stresses for beams or slabs must be calculated by the accepted formulas of modern engineering practice.

Working stresses.

33.—Except as provided for in pillars, the safe working stresses on concrete shall not exceed the following:—

	Proportion by volume.					
Stresses on concrete.	Cement.	Sand.	Coarse material.	Cement.	Sand.	Coarse material.
	1	2	4	1	1½	3
	Stress in lb. per sq. in.			Stress in lb. per sq. in.		
Direct compressive stress	600			700		
Extreme fibre stress	600			700		
Frictional stress between concrete and steel	100			100		
Shearing stress on plane sections ...	60			60		
Tensile stress	nil.			nil.		

34.—

Stresses on mild steel complying with the British Standard Specification.	Lbs. per sq. in.
Direct compressive stress = $m\,c$ where m = modular ratio, and c = safe working compressive stress (in lb. per sq. in.) on concrete surrounding the steel	$m.c.$
Direct tensile stress on mild steel in longitudinal members	17,000
Tensile stress in web-reinforcement	12,000
Shearing stress on mild steel	12,000

35.—Provision shall be made for the stresses due to eccentric loading.

36.—The algebraic sum of the stresses in any member subject to eccentric loading shall not exceed the maximum permissible direct stress.

37.—The term "combined stresses" when used in these regulations shall mean the algebraic sum of all the stresses, eccentric and direct, and any other stresses due to any cause or causes.

Neither the steel nor the concrete shall be subjected to combined stresses which together exceed the maximum permissible direct stress.

38.—Every member subject to alternating tensile and compressive stresses shall be designed and proportioned to resist the maximum for each stress.

39.—All joints in or between reinforced concrete members shall be designed and arranged so that the stresses which may come upon them shall be within the limits allowed by these regulations.

40.—The concrete may be assumed to take up a shearing stress of 60 lb. per square inch, but any remaining shear shall be provided for by the reinforcement.

Grip length.

41.—The grip length or adhesion length of a bar embedded in concrete shall be measured along the bar from any given cross section to the end of the bar.

42.—The grip or adhesion length (in inches) shall not be less than

$2{\cdot}5\,td$ for round or square bars, or

$\frac{5\,bdt}{b+d}$ for rectangular bars,

Where

b = the *breadth* of the bar in inches.

d = the least *diameter* of the bar in inches.

t = the *tensile* stress (in thousands of pounds per square inch) at the given cross section.

Additional security shall be provided by fish-tailing the ends of the bars or by bending the ends of the bars into a J form, or by mechanical bond.

In the case of a bar having mechanical bond the least diameter of the bar may be measured from outside to outside of the transverse projections provided—

(*a*) That the transverse projections are not farther apart (centre to centre) than twice the normal diameter of the bar;

(*b*) That the height of such projections above the normal surface of the bar shall be at least $\frac{1}{16}$th of an inch on all bars exceeding one-half inch in diameter and 1-32nd of an inch on all bars not exceeding one-half inch in diameter.

Modular ratio.

43.—The term "modular ratio" (m) means the ratio of the elastic modulus of steel to the elastic modulus of concrete.

44.—The elastic modulus for steel in tension or compression shall be taken at thirty million pounds per square inch.

45.—The elastic modulus for concrete in compression or tension shall be taken at two million pounds per square inch.

46.—The modular ratio for steel and concrete shall be taken at 15.

PART III.

BEAMS.

47.—The term "beam" shall include any beam, girder, lintel, bressummer or cantilever, or any other similar member carrying transverse loads.

48.—The least diameter or thickness of the longitudinal bars in beams shall not be less than one-quarter of an inch. Wiring may be used solely for holding the bars during the process of placing the concrete in position.

49.—All other reinforcements in beams shall be at least one-eighth of an inch in diameter or thickness.

50.—There shall be a distance of at least one inch between the bars in beams except at joints or in cases where the bars are bound close together throughout the length in contact and have both ends properly turned up in the form of a hook.

51.—The maximum distance between the bars of the tensile reinforcement in beams shall not be greater than twelve inches.

Compressive reinforcement.

52.—Where compressive reinforcement is provided in beams the sectional area of the beam in the plane of the reinforcement may be assumed to be increased by fourteen times the cross sectional area of the steel in compression.

53.—Where compressive reinforcement is provided and calculated to take part of the compression it must be anchored by bars extending through the middle third of the effective depth of the beam.

54.—The anchors shall not be farther apart (centre to centre) than the effective depth of the beam.

Shear reinforcement.

55.—All beams shall be provided with adequate shear members and such shear members shall—

(*a*) Be spaced according to the distribution and intensity of the shearing stresses, but the distance from centre to centre of the shear reinforcement at any part of the beam shall not exceed the effective depth of the beam.

(*b*) At least extend from the centre of the tensile reinforcement to the centre of pressure in the concrete under compression.

(*c*) Be passed under or round the tensile reinforcement or be otherwise secured thereto.

(*d*) Have a mechanical anchorage at both ends, or they shall have a mechanical bond with the concrete throughout their length.

Brackets at ends of beams and bracketed work.

56.—In cases where splayed work is provided under the ends of beams such work shall be in addition to the support required by these regulations.

57.—In cases where bracketed work is necessary and provided to carry loads, it shall be reinforced sufficiently to provide for the stresses due to such loads.

SLABS.

58.—The effective depth of slabs shall be measured from the compressed edge of the constructional concrete to the centre of gravity of the tensile reinforcement.

59.—The least diameter or thickness of main reinforcing bars in slabs shall not be less than one-quarter of an inch. Wiring may be used solely for holding the bars during the process of placing the concrete in position.

60.—All other reinforcement in slabs shall be at least one-tenth of an inch in diameter or thickness.

61.—There shall be a distance of at least one inch between bars in slabs except at joints and at points where the bars are in direct contact and transverse to one another.

62.—All meshed reinforcement shall be of such dimensions as will enable the coarse material in the concrete to pass easily through the meshes of such reinforcement.

63.—The maximum distance between bars or strands of the tensile reinforcement in slabs shall not be greater than 12 inches.

RESISTANCE MOMENTS.

64.—The resistance moment of reinforced concrete construction under transverse loads shall be determined by formulas based on the following assumptions—

(*a*) All tensile stresses shall be taken by the steel.

(*b*) The strain in any fibre is directly proportionate to the distance of that fibre from the neutral axis.

(*c*) The tensile elastic modulus of concrete shall be assumed to be equal to the compressive elastic modulus of that material.

(*d*) The elastic moduli of the concrete remain constant within the limits of the working stress.

(*e*) The stress-strain curve or graph is a straight line.

(*f*) The grip between the concrete and steel is sufficient to make the two materials act together.

65.—

Notation.

A_t = *Area* of *tensile* reinforcement (in square inches).

a = the *arm* of the resistance moment (in inches).

B = *Bending* moment of the external loads and forces.

b = *breadth* of rectangular beam in inches, or the breadth of the flange of a tee beam in inches.

c = *compressive* safe working stress on the extreme edge of the concrete in compression (in lb. per square inch).

d_s = total *depth* of *slab* in inches.

d = the effective *depth* of the beam in inches, *i.e.*, the distance from the compressed edge of the constructional concrete of the beam to the common centre of gravity of the tensile reinforcement.

E_c = *Elastic* modulus of *concrete* in compression.

E_s = *Elastic* modulus of *steel* in tension.

l = the *length* of the effective span of a beam.

$m = \frac{E_s}{E_c} = 15$ = *modular* ratio.

n = the distance of the *neutral* axis from the compressed edge of the constructional concrete of the beam (in inches).

$n_1 = \frac{n}{d}$ = *neutral* axis ratio, $\therefore n_1 d = n$.

p = the *percentage* of tensile reinforcement $= 100r$.

R = *Resistance* moment of the internal stresses in the beam.

r = *ratio* of A_t to bd, i.e., $r = \frac{A_t}{bd}$ and $A_t = rbd$.

s_1 = *slab* depth ratio $= \frac{d_s}{d}$

t = *tensile* working stress on steel in tensile reinforcement (in lb. per square inch of cross section).

W = the total *weight* to be carried by a beam.

Rectangular and tee beams.

66.—In the case of rectangular beams and tee beams when the neutral axis is within the slab, *i.e.*, tee beams in which r is less than

$$\frac{s_{\prime}^2}{2m(1-s_{\prime})}$$

the position of the neutral axis shall be obtained from the equation—

$$n_{\prime} = \sqrt{(m^2r^2+2mr)} - mr$$

and

$$n = [\sqrt{(m^2r^2+2mr)} - mr]d$$

67.—The mean compressive stress on the concrete shall be taken at $\frac{c}{2}$

68.—The arm of the resistance moment shall be obtained from the equations—

$$a = d - \frac{n}{3} \text{ or}$$

$$a = d\left(1 - \frac{n_{\prime}}{3}\right)$$

69.—The tensile resistance moment shall be obtained from the equations—

$$R_t = tA_t\left(d - \frac{n}{3}\right) \text{ or}$$

$$R_t = tA_td\left(1 - \frac{n_{\prime}}{3}\right) \text{ or}$$

$$R_t = trbd^2\left(1 - \frac{n_{\prime}}{3}\right)$$

70.—The compressive resistance moment shall be obtained from the equations—

$$R_c = \frac{c}{2}bn\left(d - \frac{n}{3}\right) \text{ or}$$

$$R_c = \frac{cbd^2}{2}n_{\prime}\left(1 - \frac{n_{\prime}}{3}\right)$$

Tee beams.

71.—For the purpose of computing the resistance moment of a tee beam, the width of the flange shall not be taken at more than—

(*a*) One-third of the effective span of the tee beam;

(*b*) Three-fourths of the distance between the centres of the ribs of the tee beams;

(*c*) Six times the width of the rib of the tee beam;

(*d*) Fifteen times the thickness of the slab;

whichever is the least.

72.—When a part of a slab is taken as forming part of a tee beam, the reinforcement in the slab transverse to the beam must cross the full width of the portion of the slab forming the flange of the tee beam.

73.—All tee beams shall be reinforced against shearing stress along the plane of junction of the rib and the flange.

74.—In the case of tee beams, when the neutral axis intersects the rib, *i.e.*, tee beams in which r is greater than

$$\frac{s_{\prime}^2}{2m\ (1-s_{\prime})}$$

the position of the neutral axis shall be obtained from the equation

$$n_{\prime} = \frac{s_{\prime}^2 + 2\ mr}{2\ (s_{\prime} - mr)}$$

75.—The mean compressive stress shall not be taken at more than

$$c\left[1-\frac{s_1}{2n_1}\right] \text{ or}$$

$$\frac{cmr\,(2-s_1)}{s_1^2+2mr}$$

76.—The arm of the resistance moment $= a$ where

$$a = d\left[1-\frac{s_1}{3}\left(\frac{3n_1-2s_1}{2n_1-s_1}\right)\right] \text{ or approximately}$$

$$a = d - \frac{d_s}{2}$$

77.—The compressive resistance moment $= \mathrm{R}_c$ where

$$\mathrm{R}_c = c\left[1-\frac{s_1}{2n_1}\right] bd_s a \text{ or}$$

$$\mathrm{R}_c = cbd_s d\left[\frac{s_1^3+4mrs_1^2-12mrs_1+12mr}{6\,(s_1^2+2mr)}\right]$$

78.—The tensile resistance moment $= \mathrm{R}_t$ where

$$\mathrm{R}_t = t\mathrm{A}_t a \text{ or}$$

$$\mathrm{R}_t = tbd^2\left[\frac{s_1^3+4mrs_1^2-12mrs_1-12mr}{6m(2-s_1)}\right]$$

79.—A note shall be added to the drawings of all pillars and beams showing the loads which have been provided for.

PART IV.

PILLARS.

80.—The term "pillar" when used in these regulations shall be deemed to include any pillar, pier, post, column, detached support, or any other vertical compression member.

81.—Pillars shall be designed on the assumption that the concrete and the vertical bars are shortened in length in the same proportion.

82.—In calculating the strength of a pillar, the maximum value of the ratio of length to effective diameter shall be taken.

83.—The length shall be measured between the lateral supports, irrespective of any splayed work.

84.—The effective diameter shall be measured to the outside of the outermost vertical reinforcement and shall be measured in the direction of the lateral supports which determine the length of the pillar.

85.—A pillar shall be deemed to have fixed ends when the ends of the pillar are sufficiently secured to other parts of the construction having such rigidity as will maintain the axis of the pillar at the ends in its original vertical position under all loads less than the crippling load.

86.—When both ends are fixed and when the ratio of length to the effective diameter does not exceed—

18	... ...	The full stress may be allowed on the pillars.		
21	... ...	·8 of above may be allowed.		
24	... ...	·6 ,,	,,	,,
27	... ...	·4 ,,	,,	,,
30	... ...	·2 ,,	,,	,,

For other ratios the stress shall be proportionate to the above.

87.—In the case of compression members not having both ends fixed, the loads shall be as follows:—

Let P = the maximum permissible *pressure* on pillars and compression members having fixed ends.

Condition of ends.	Working load.
One end fixed and one end hinged...	$\frac{P}{2}$
Both ends hinged	$\frac{P}{4}$
One end fixed and the other end free and not guided, stayed or supported in all directions	$\frac{P}{16}$

88.—Each pillar with rectilinear laterals shall have at least four lines of vertical reinforcement throughout its entire length.

89.—Each pillar with curvilinear laterals shall have at least six lines of vertical reinforcement throughout its entire length.

90.—The diameter of vertical rods shall not be less than $\frac{1}{2}$ inch nor greater than 2 inches.

91.—The least diameter of rectilinear laterals (hooping) shall not be less than $\frac{3}{16}$ths of an inch.

92.—The least diameter of curvilinear laterals (hooping) shall not be less than $\frac{1}{8}$th of an inch.

93.—The pitch of the laterals shall not exceed $\frac{6}{10}$ths of the effective diameter of the pillars.

94.—Joints in the vertical reinforcement of pillars shall only be made at a floor level or other point of lateral support.

95.—All joints in the vertical reinforcement shall be provided with steel or iron

(*a*) Close-fitting sleeves, or

(*b*) Clamps, or

(*c*) Properly bound splices having an overlap at least equal to forty times the least diameter of the bar, or

(*d*) Flitch or fish bars having the grip length on either side of the joint at least equal to forty times the least diameter of the bar.

96.—In the case of rectangular pillars in which the ratio between the greater and the lesser diameter exceeds one and a half, the cross section of the pillar shall be subdivided by cross-ties, and the number of vertical rods shall be such that the distance between the rods along the longer side of the rectangle shall not exceed the distance between the rods along the shorter side of the rectangle.

97.—The total cross-sectional area of the vertical reinforcement in any pillar shall not be less than 0·8 per cent. of the area of the hooped core.

98.—The volume of lateral reinforcement shall not be less than 0·5 per cent. of the volume of the hooped core.

99.—The stress on the concrete in the area bounded by the lateral reinforcement shall not exceed—

$$W_f u\,[1+fsr] \text{ where}$$

W_f = the *working factor* = the reciprocal of the safety factor $= \frac{1}{Sf}$

Sf = the *safety factor* $= 4$.

u = the *ultimate crushing* resistance of concrete at three months.

f = *form* factor, depending upon form or type of laterals (see table).

s = *spacing* factor depending upon the spacing or pitch of the laterals (see table).

r = *ratio* of the volume of lateral reinforcement to the volume of the hooped core in any given length of pillar.

$Wf\ u = \frac{1}{4}$ of the ultimate compressive resistance of concrete at ninety days after mixing as given in item No. (132).

100.—

Table showing the value of fs.

Form of lateral reinforcement.	Form factor *f*.	Spacing of laterals in terms of diameter of hooped core.	Spacing factor *s*.	Value of *fs*.
Helical	1.	·2*d*	32	32
Helical	1.	·3*d*	24	24
Helical	1.	·4*d*	16	16
Circular hoops	·75	·2*d*	32	24
Circular hoops	·75	·3*d*	24	18
Circular hoops	·75	·4*d*	16	12
Rectilinear	·5	·2*d*	32	16
Rectilinear	·5	·3*d*	24	12
Rectilinear	·5	·4*d*	16	8
Rectilinear	·5	·5*d*	8	4
Rectilinear	·5	·6*a*	0	0

101.—The safe load on pillars shall be obtained from the equation—

$P = c\ [A + (m - 1)\ A_v]$ where

P = Total permissible *pressure*.

c = working *compressive* stress on the concrete of the hooped core.

A = effective *area* of the pillar—*i.e.*, the area bounded by the lateral reinforcement measured to the inside of the hooping.

A_{vl} = *Area* of the *vertical* reinforcement.

m = *modular* ratio $= \frac{E_s}{E_c}$

102.—The following limits of stress shall be observed in pillars :—

(*a*) The stress on the metal reinforcement (*i.e.*, the value of mc) shall not exceed 0·5 of the elastic limit of the metal;

(*b*) The stress on the metal reinforcement shall not exceed one-fourth of the ultimate statical tensile strength of the metal;

(*c*) Notwithstanding any other provision of these regulations, the working stress on the concrete of pillars shall not exceed the following values, whatever the percentage of lateral reinforcement :—

Form of laterals.	Limiting value of working stress.
Rectilinear	0·5*u*
Independent circular hoops	0·58*u*
Helical	0·66*u*

PART V.

WALLS.

103.—Where the dead loads and superimposed loads are transmitted to the foundations by a series of reinforced concrete pillars, beams, arches, or other construction designed and reinforced under these rules, any external enclosing walls of reinforced concrete between such pillars may be of any thickness not less than four inches provided that such enclosing walls are designed and reinforced under these rules to resist any loads and pressures they may have to carry.

104.—In any case where any wall or part of a wall is intended to support vertical loads or resist lateral pressures, it shall be of such thickness as may be necessary to keep the stresses within the limits prescribed by these rules for the construction of pillars, beams, and other members.

105.—When portions of the external walls between the reinforced concrete pillars and beams are constructed of brickwork, or stonework or plain concrete, such portions of walls shall be of a thickness not less than 8½ in. for the topmost 20 ft. of their height and 13 in. for the remainder of their height below such topmost 20 ft.

When walls are constructed of hollow concrete blocks the total thickness shall not be less than 8½ in. nor the hollow space more than 3 in.

Provided that a less thickness shall be allowed in any case in which under the London Building Act, 1894, such less thickness is prescribed, and provided that in any case in which an external wall or portion of an external wall is not supported or carried or secured by the reinforced concrete skeleton framed construction within the limit of height and length prescribed by the First Schedule to the London Building Act, 1894, for the purpose of determining the thickness of walls, such external wall or portion of external wall shall be of a thickness not less than that prescribed by such schedule.

106.—All walls and facing materials shall be securely connected to the pillars, beams, floors and other contiguous parts of the reinforced concrete construction.

107.—Each panel in any external wall shall be designed to resist safely a horizontal pressure of at least thirty pounds per square foot assumed to be acting uniformly over the area of one panel from either side.

108.—Openings of larger aggregate area than allowed by the principal Act may be made in external walls provided—

(*a*) That the aggregate area of such openings in a wall of any storey above the ground storey will not exceed two-thirds of the whole area of the wall of such storey.

(*b*) That the aggregate width of such openings in a wall of any storey above the ground storey will not exceed three-quarters of the whole length of the wall of such storey.

109.—Party walls and division walls constructed in reinforced concrete in accordance with these regulations shall be of such thickness as may be necessary to comply therewith, but in no part shall such wall be of less thickness than 8 in.

110.—Provided that any such party wall between a building constructed in reinforced concrete and a building (of the warehouse class) constructed in accordance with the Rules of the Act of 1894, or as a steel-framed building, shall not be in any part less than 13 in. in thickness.

111.—The pressure on any brickwork shall not exceed the following :—

	Tons per sq. ft.
Blue brick in cement mortar...	12
Hard brick (including London stock) in cement mortar	8
Ordinary brick in cement mortar	5

Such brickwork shall not have a height without proper lateral supports of more than six times its least thickness, but any such brickwork with proper supports may have a height between such lateral supports not more than twelve times the least thickness of such brickwork. Such thickness shall in no case be less than thirteen and a half inches.

PART VI.

FOUNDATIONS.

112.—The pressure of foundations on the natural ground shall not exceed the following :—

	Tons per sq. ft.
Natural bed of soft clay or wet or loose sand	1
Natural bed of ordinary clay or confined sand	2
Natural bed of compact gravel, London blue clay or chalk	4

113.—The pressure on plain concrete in foundations shall not exceed twelve tons per square foot.

PART VII.

PROTECTION.

114.—The cover shall be measured from the outer surface of the concrete to the outer surface of the metal reinforcement.

115.—The cover of vertical bars in pillars shall not be less than 1½ in. and not less than the diameter of such vertical bar.

116.—The cover of longitudinal bars in beams shall not be less than one inch and not less than the diameter of such longitudinal bars.

117.—The cover of tensile, compressive, shear or any other reinforcement in slabs shall not be less than one-half inch, and not less than the diameter of the bars in such reinforcement.

PART VIII.

MATERIALS.

Cement.

118.—All cement used shall be Portland cement of slow setting quality and shall be in accordance with the British Standard Specification from time to time in operation.

119.—The quantity of cement shall be determined by weight and ninety pounds shall be deemed to be the equivalent of one cubic foot.

Sand.

120.—The sand shall be clean and gritty and composed of hard silicious grains.

It shall be free from clay or any animal or vegetable matter.

121.—All sand shall pass through a mesh three-sixteenths of an inch square measured in the clear.

122.—The sand shall be separated from the coarse material before the materials are measured.

Coarse Material.

123.—The term "coarse material" means all the ingredients of the concrete except the cement and the sand.

124.—The coarse material shall consist of clean Thames or pit-ballast or gravel, hard stone, granite, basalt, trap rock, broken hard brick or other equally hard suitable material to be approved by the District Surveyor.

125.—The following materials shall not be used with the sand or coarse material in the composition of the concrete under these regulations :—

(*a*) Coal residues, including clinkers, cinders, ashes, coke breeze, pan breeze, slag and other similar material.

(*b*) Blast furnace slag, copper slag, forge breeze, dross and other similar material.

(*c*) Sulphates, including plaster of Paris, and other similar materials.

(*d*) Limestones, magnesian limestones, marbles and other calcium carbonates.

126.—Unless quite clean all ballast or gravel shall be thoroughly washed.

127.—The coarse material shall be of such a size as will pass through a mesh three-quarters of an inch square measured in the clear and be retained on a mesh three-sixteenths of an inch square measured in the clear.

128.—The coarse material shall be varied in size as much as possible between the limits of size allowed for the work, but shall not be larger than such as can pass between the reinforcement and between the reinforcement and the centering.

129.—The coarse material if of a porous nature shall be thoroughly wetted before being mixed with the cement mortar.

130.—The volume of mortar shall be at least 15 per cent. in excess of what would be required to fill completely the interstices and voids of the coarse material.

131.—The volume of coarse material shall not be more than twice the volume of sand.

Concrete.

132A.—The concrete shall be composed of cement, sand and coarse material in one of the following or intermediate proportions and the ultimate compressive resistance shall not be less than that specified for the proportion adopted :—

Proportion by volume.			Ultimate compressive resistance in lb. per sq. in.	
Cement.	Sand.	Coarse material.	28 days after mixing.	90 days after mixing.
1	2	4	1,800	2,400
1	1½	3	2,100	2,800
1	1	2	2,700	3,600

132B.—The ultimate compressive resistance of concrete of materials mixed in intermediate proportions may be estimated from the following equation—

$$u = 12 + \frac{72}{V_i} \text{ where}$$

u = *ultimate* compressive resistance at 90 days in hundreds of pounds per square inch.

V_i = *Volume* of *inert* material per unit volume of cement.

133.—All three materials should be thoroughly mixed dry, and then thoroughly mixed again after wetting.

134.—The concrete must be placed in its final position before initial set has taken place.

In the case of beams, pillars and walls the thickness of the layers of loose concrete shall not exceed three inches before ramming.

As soon as possible after mixing, the concrete shall be properly rammed into the moulds in such a manner and under such conditions as will secure a compact mass, without voids and of the greatest possible density for the proportions used.

Steel.

135.—All metal reinforcement shall be of steel which shall comply with the British Standard Specification for structural steel for bridges and general building construction from time to time in operation; or shall be of any other structural steel which may hereafter be standardized by the Engineering Standards Committee.

136.—The working tensile stress on such other structural steel which may hereafter be standardized shall not exceed—

(*a*) One-fourth of its ultimate resistance;
(*b*) One-half the stress at the yield point of the steel;
(*c*) 20,000 lbs. per square inch;

whichever is the least.

137.—Steel having a greater ultimate tensile resistance than seventy-two thousand pounds per square inch shall have an efficient continuous mechanical bond with the concrete in which—

(*a*) the transverse projections are not further apart (centre to centre) than twice the normal diameter of the bar;

(*b*) the height of such projections above the normal surface of the bar shall be at least $\frac{1}{16}$th of an inch on all bars exceeding half-inch in diameter and $\frac{1}{32}$nd of an inch on all bars not exceeding half-inch in diameter.

138.—All metal for reinforcement shall be cleaned of all scale dust and loose rust, and, if coated, it shall be thoroughly coated with one coat of Portland cement wash of adequate consistency immediately before depositing the concrete.

139.—End welding shall not be allowed in any tensile reinforcement.

PART IX.

TESTS AND TESTING.

140.—The District Surveyor shall for the purpose of due supervision of the construction of a building be furnished with reasonable proof as to the quality of materials to be used in such construction and shall, if not furnished with such proof or for any other reason, require the builder or other person causing or directing the work to be executed to make any tests which the District Surveyor may consider necessary.

141.—For determining the resistance of concrete, tests shall be made on cubes of not less than four inches each way, or cylinders of not less than six inches each way.

142.—The conditions accompanying the preparation, setting, maturing and actual testing of the cube or other test piece shall as far as possible conform to the conditions that would obtain in the actual execution of the reinforced work.

143.—If at any time during the construction or within two months after the completion of the reinforced concrete construction it is found necessary to test any part of such construction by reason of any sign of weakness or faulty work appearing in the construction, the builder or other person causing or directing the work to be executed shall make such tests, and, in the event of the District Surveyor being satisfied that such construction is not as required by these regulations, it shall be reconstructed and reinstated in accordance therewith.

The measured deflection of beams under the full working load shall not exceed 1/600th of the span.

144.—The superimposed test load on any floor, roof or other structure shall be one and a half times the superimposed load for which such floor, roof, or other structure has been designed.

145.—Loading tests shall not be made until the expiry of sixty days from the date of laying the concrete.

PART X.

CENTERING.

146.—For the purpose of these regulations, the term "Centering" shall include all forms, moulds, sheeting, shuttering, planks, poles, posts, shores, struts and strutting, ties, uprights, walling and all other temporary supports to the concrete during the process of setting.

147.—The centering shall be of such dimensions and so constructed as to remain rigid during the laying, tamping and setting of the concrete.

148.—The vertical strutting shall be maintained continuous through the lower storeys to the foundations or to other floors or beams which are sufficiently set to afford the required support without injury to the construction.

149.—All centering shall be removed without shock or vibration.

150.—Before removing the centering under any beam or floor slab, the pillars below such beam or floor slab shall be partially stripped so that the pillars may be examined on all sides.

PART XI.

WORKMANSHIP.

151.—All reinforcement shall be placed and maintained in the exact position shown on the drawings.

152.—The concreting in any member shall be carried out as continuously as possible.

153.—Where work has to be recommenced on a surface which has hardened, such surface shall be well hacked, swept clean, thoroughly wetted and covered with a grout of neat cement and water or with a mortar composed of equal volumes of cement and sand.

154.—Concrete laid during hot weather shall be watered daily (Sundays and holidays included) during the first week of hardening.

155.—Concrete shall be protected during frosty weather.

156.—Concrete cement or mortar which has been frozen shall not be used again unless it has been thoroughly thawed and broken up. It shall then be considered measured and gauged as inert material only, and shall be mixed with fresh cement.

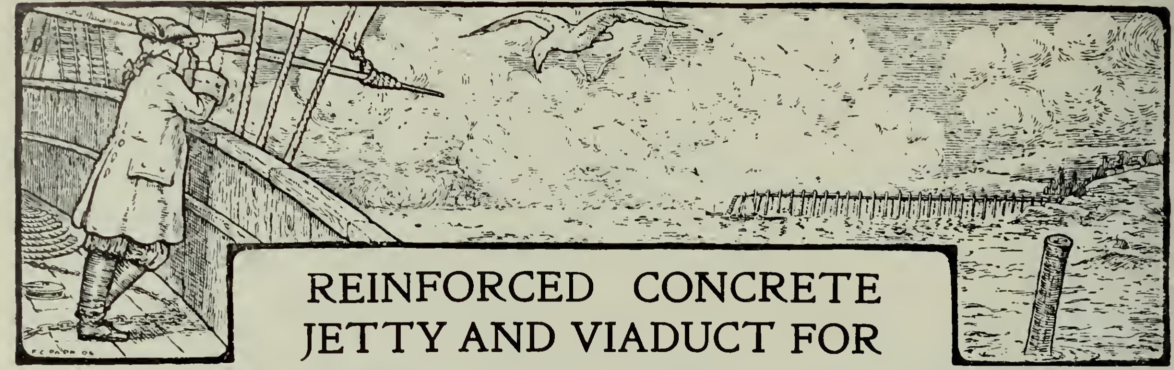
157.—All beams, slabs and other similar members which have been exposed to frost during the first week of hardening shall be tested with a superimposed load of 1½ times the superimposed working load, but ninety days shall elapse before such test is made in lieu of the sixty days required where work has been executed under normal conditions.

158.—No cutting for piping or any other purpose shall be done which would reduce the strength of any part of the structure below what is required by these regulations.

159.—Wood or other combustible material shall not be embedded in the concrete which has been provided to comply with the statical requirements of these regulations.

Blocks of coke breeze or other equally incombustible material may be allowed solely for fixing purposes provided they do not reduce the structural stability, and also provided that the area of such blocks at any given cross section is not included in the calculated compressive area of any beam, slab, pillar, or other constructional member.

160.—Wood or other combustible material may be placed on or over the surface of the constructional concrete provided that any voids or hollow spaces between the combustible and incombustible material be filled up with materials of an incombustible nature.



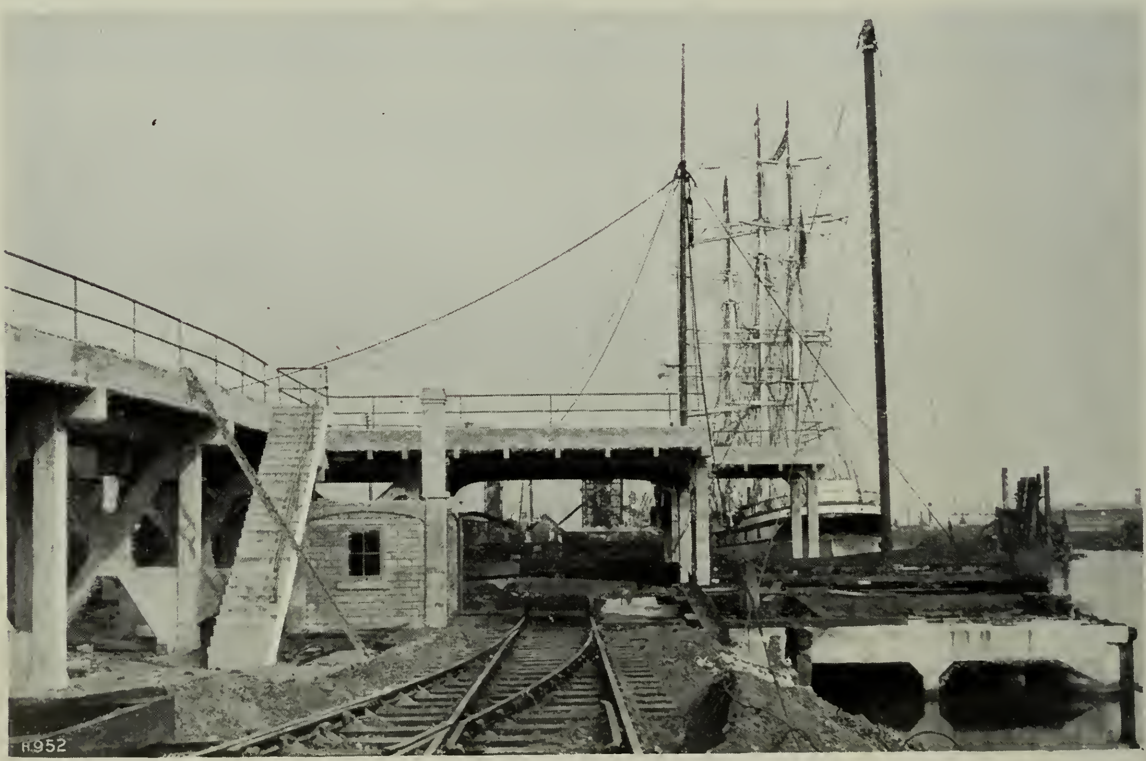
REINFORCED CONCRETE JETTY AND VIADUCT FOR HIGH LEVEL COAL HOIST AT PORT TALBOT DOCKS.

By W. CLEAVER, M. Inst. C. E.

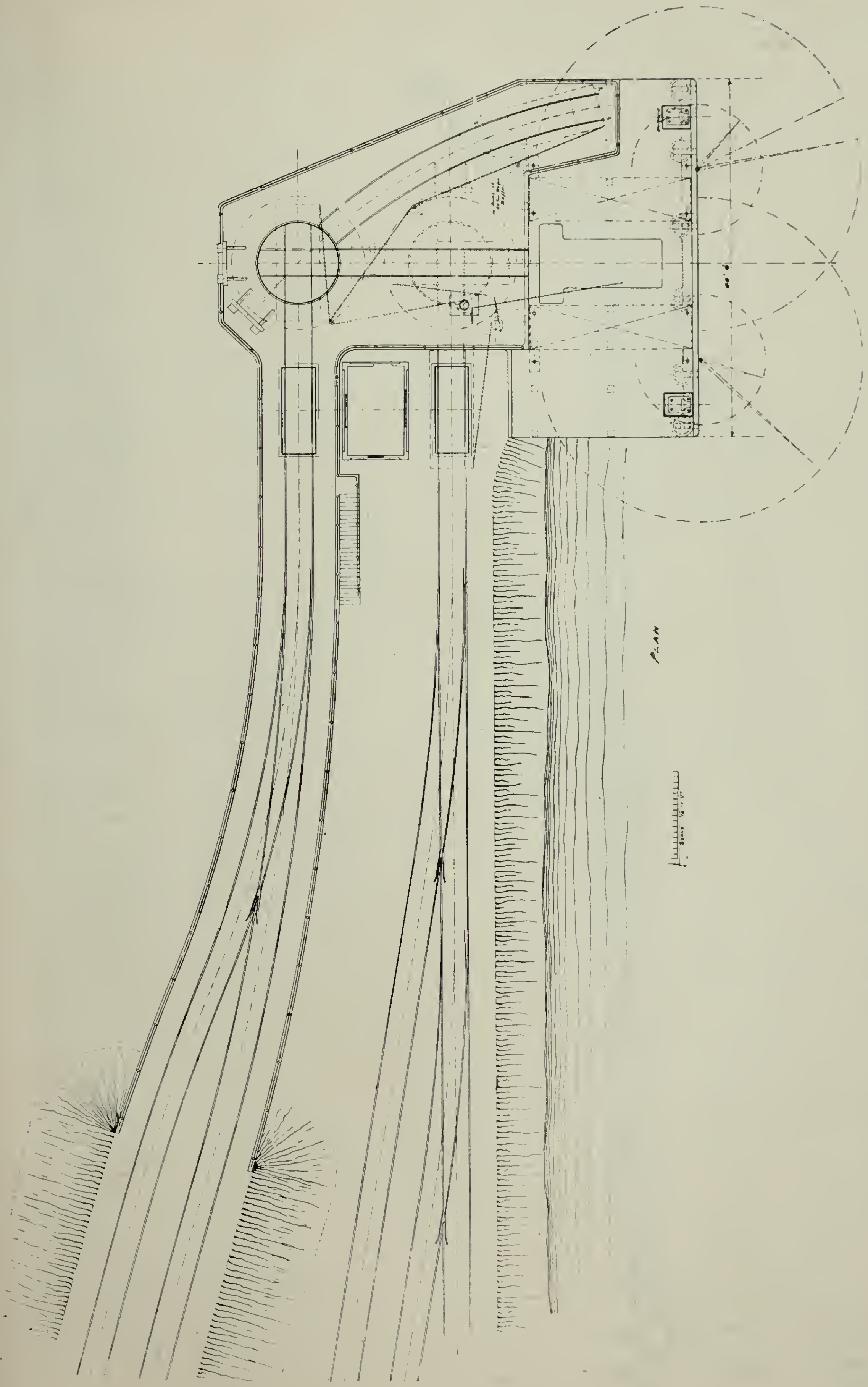
We give an interesting example in this article of the use of reinforced concrete for dock work, and hope at a later date to give an account of the other reinforced concrete structures being carried out for the Port Talbot Railway and Docks Company.—ED.

In Concrete and Constructional Engineering for March, 1907, there was a description of the construction, tests, etc., of what constituted at that time the first reinforced concrete jetty built for the erection of Dock Coal Tips. Since then a great number have been built for similar purposes at various docks, and sundry works in reinforced concrete have also been carried out since at Port Talbot Docks for the Port Talbot Railway and Docks Company.

Recently, however, a fairly important jetty has been completed and



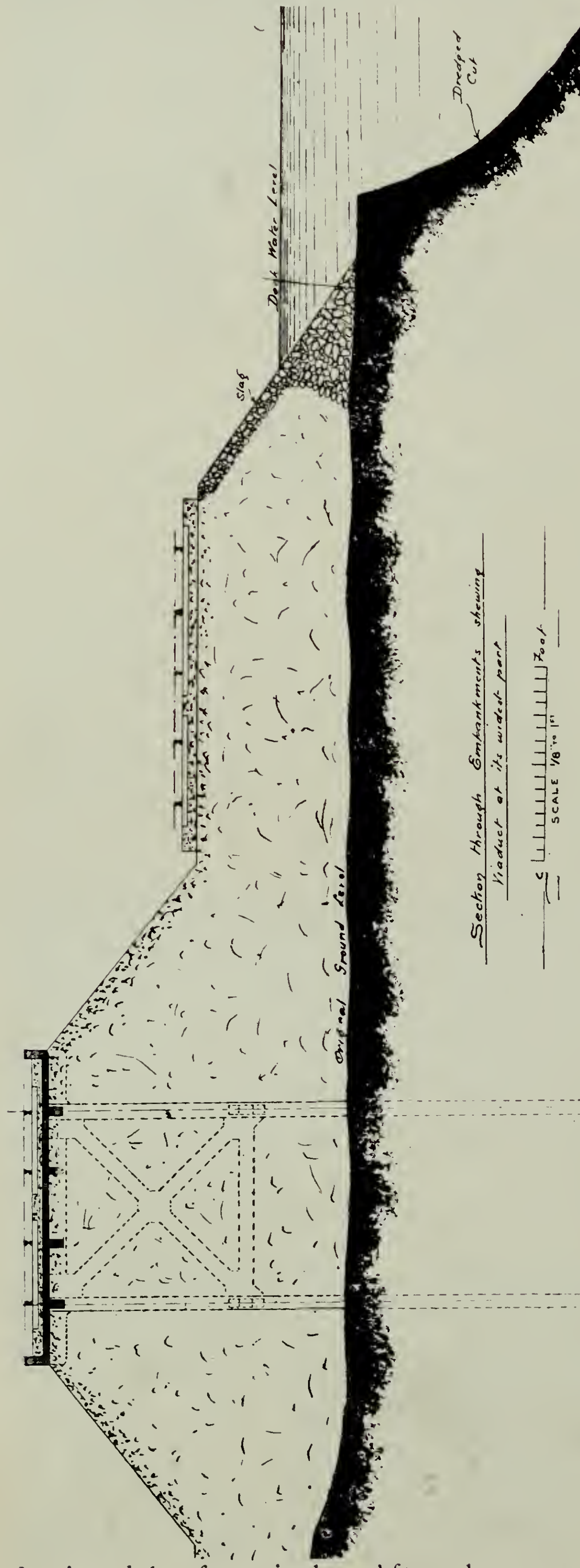
View of Jetty and Viaduct before erection of Hoist.
Reinforced Concrete Jetty and Viaduct at Port Talbot Docks.



General Plan.

Reinforced Concrete Jetty and Viaduct at Port Talbot Docks.

brought into use in the old portion of the docks, on which is erected one of the very latest coal tips in the country.



Section of Viaduct through Embankment.

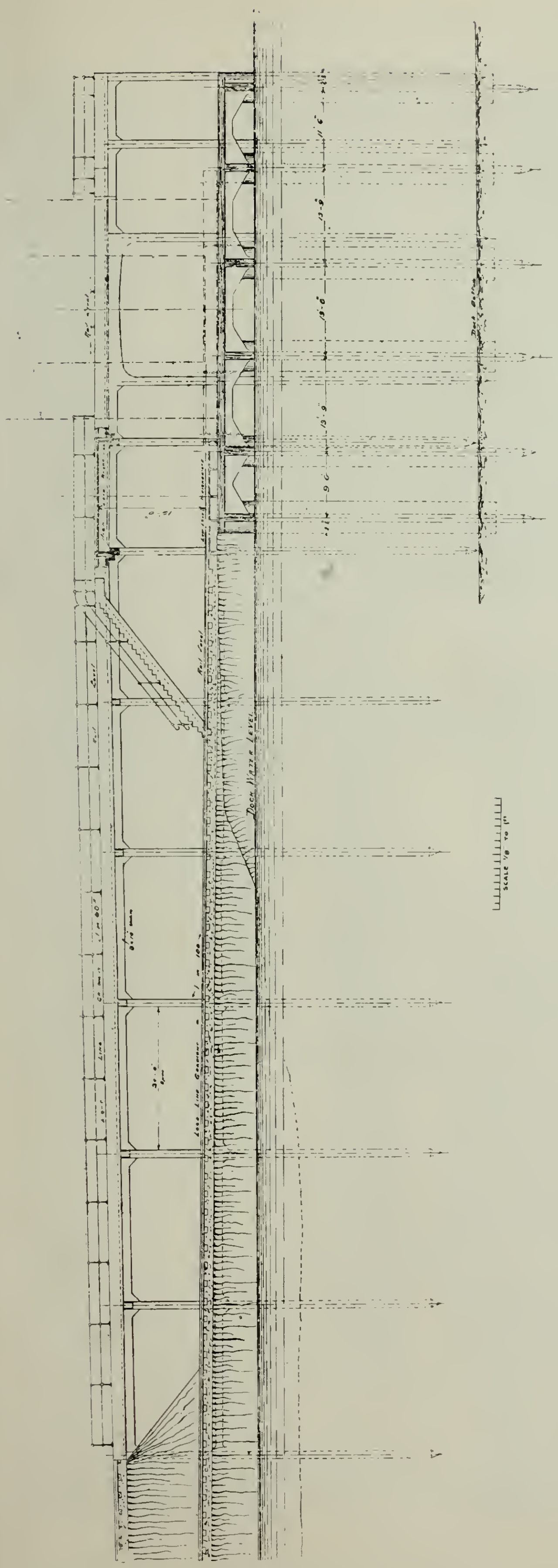
Reinforced Concrete Jetty and Viaduct at Port Talbot Docks.

Port Talbot Docks, one of the oldest docks in the Bristol Channel, has during the last decade been very much enlarged and brought up to date, and the work described in this article is only one of a number of extensions and improvements still being carried out in order that the greatly increased traffic, due to the proximity of the docks to the South Wales coalfields, can be dealt with expeditiously and economically.

The Reinforced Concrete Jetty and Viaduct in question have been designed and built on the Hennebique principle so far as the steel reinforcement is concerned.

The jetty proper—that is, the portion beneath the steel superstructure of the hoist—was designed for a working load of 8·5 cwt. per super. ft., over an area of 720 super. ft., and the test-load, consisting of rails and sleepers, amounted to 500 tons, distributed over the same area, equivalent to 13·9 cwt. per super. ft., or 65 per cent. in excess of the working load.

The result of the test was very satisfactory, the maximum deflection of the decking being $\frac{3}{16}$ths of an inch, and the average deflection $\frac{1}{8}$th of an inch. After the removal of the load the decking resumed its normal position, showing that there was no permanent set.



General Elevation.

Reinforced Concrete Jetty and Viaduct at Port Talbot Docks.

The Reinforced Concrete Approach Viaduct was designed for a gross working load of a 20-ton standard coal wagon, but for the test a 44-ton six-wheel coupled saddle tank locomotive was used. One of the centre and longest beams of the Viaduct was chosen for the test, this member being 16 in. deep by 8 in. wide, with a clear span of 20 ft., and a 5-in. reinforced concrete decking above.

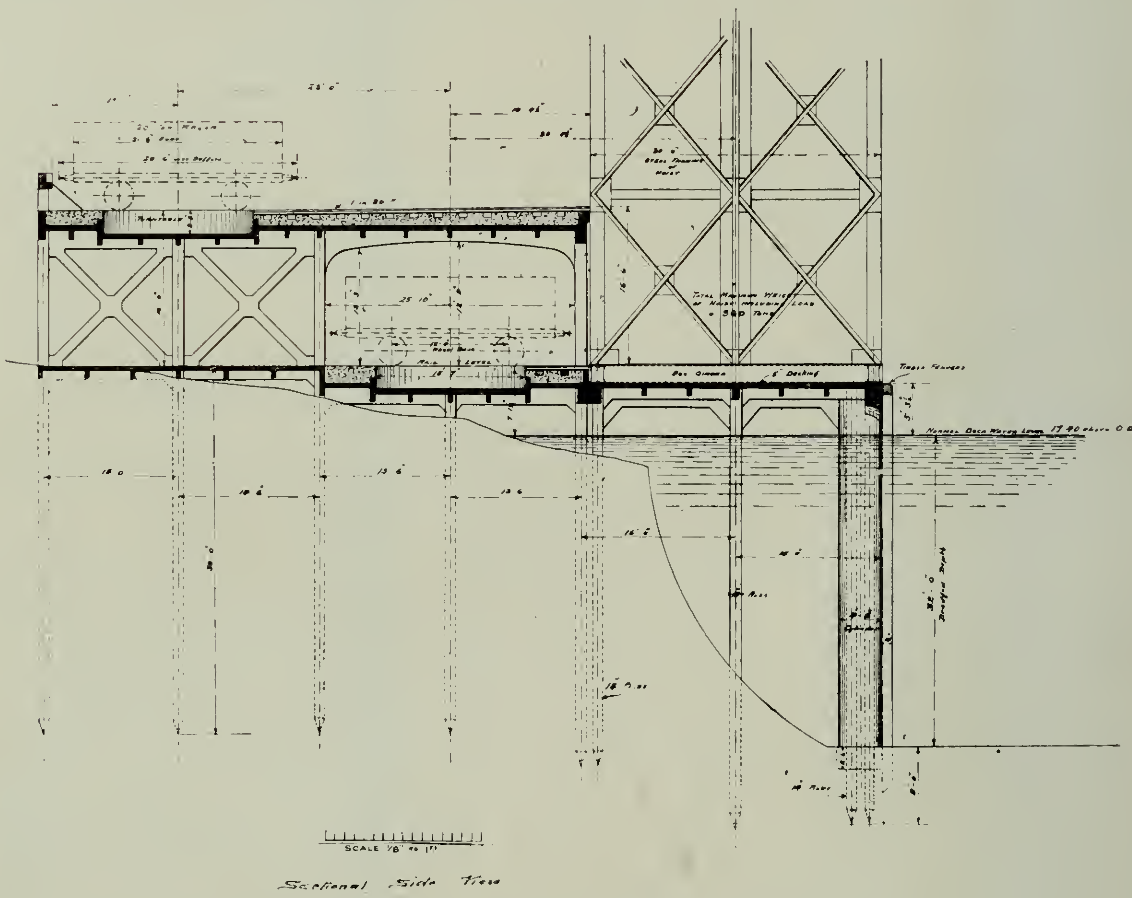
The maximum deflection registered by the Deflectometer, both with loco. running and standing, was 5-64 of an in., which is practically 1-3,000 of the span, as against the specified limit of 1-600 of the span. When the load was removed the beam resumed its normal position without any permanent set.

The author can vouch for the above tests as they were carried out under his personal direction and supervision.

The jetty consists of a number of 14-in. square reinforced concrete piles, driven through hard boulder gravel to an average depth of 8 ft. below dock bottom. Owing to the considerable depth of 32 ft. of water without lateral bracing, and in order to resist shear stresses due to vessels coming in contact with the jetty, the front piles were driven in pairs, and afterwards each pair was encased with 4-ft. 6-in. diameter by 4-in. thick reinforced concrete cylinders, the space between piles and cylinders being filled in with vertical rods and mass concrete. This arrangement forms a number of rigid columns, each with a large cross-sectional area.

As a further precaution, and in order that the inevitable wear and tear due to abrasion can be repaired at minimum cost, the actual front of the Jetty is faced with vertical and longitudinal elm fenders, the verticals being driven into dock bottom as piles.

Most of the piles were driven off a stage formed by a number of timber balks, the ends of which were firmly secured to the shore on one side, and the other side to a floating barge placed parallel to the face of the Jetty and well clear of same. The barge was fully loaded with ballast so as to make the stage as rigid and devoid of lateral movement as possible.

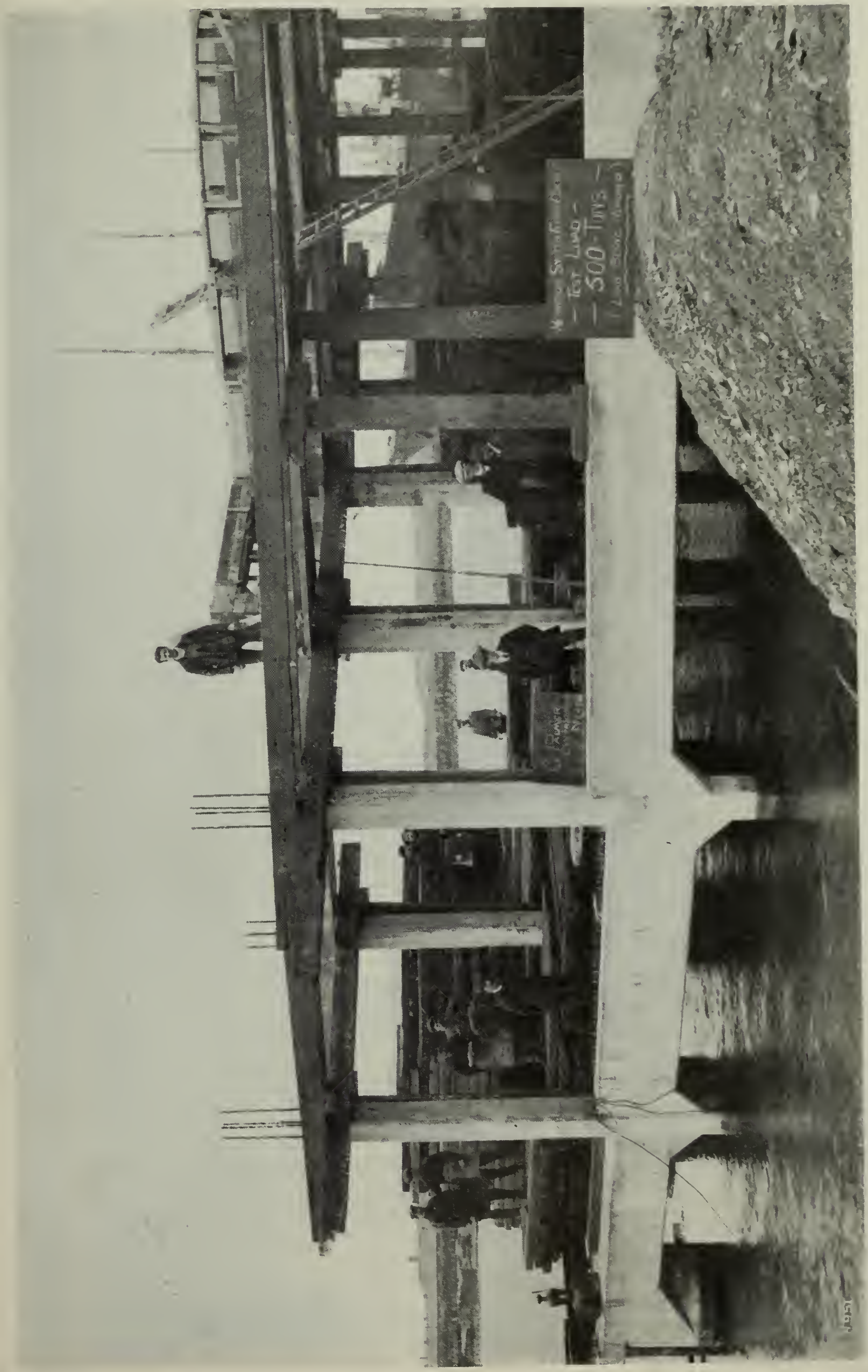

Total Maximum Weight of Hoist including Load = 500 Tons
Box Girders
6" Decking
Timber Fenders
Normal Dock Water Level 17·40 above O.D.
16' 6"
25' 10"
SCALE 1/8" to 1'
Sectional Side View

Cross-sectional view of Jetty with portion of Hoist.
REINFORCED CONCRETE JETTY AND VIADUCT AT PORT TALBOT DOCKS.

The monkey (which was 2 tons in weight) was manipulated by an ordinary steam crane winch, but was allowed a clear drop of 6 ft. by means of an ordinary hand nippers, and the specified maximum set was 1 in. to ten blows for the last forty to fifty blows. In order to penetrate the hard gravel, however, drops of 8 and even 9 ft. were given without injury to the piles.

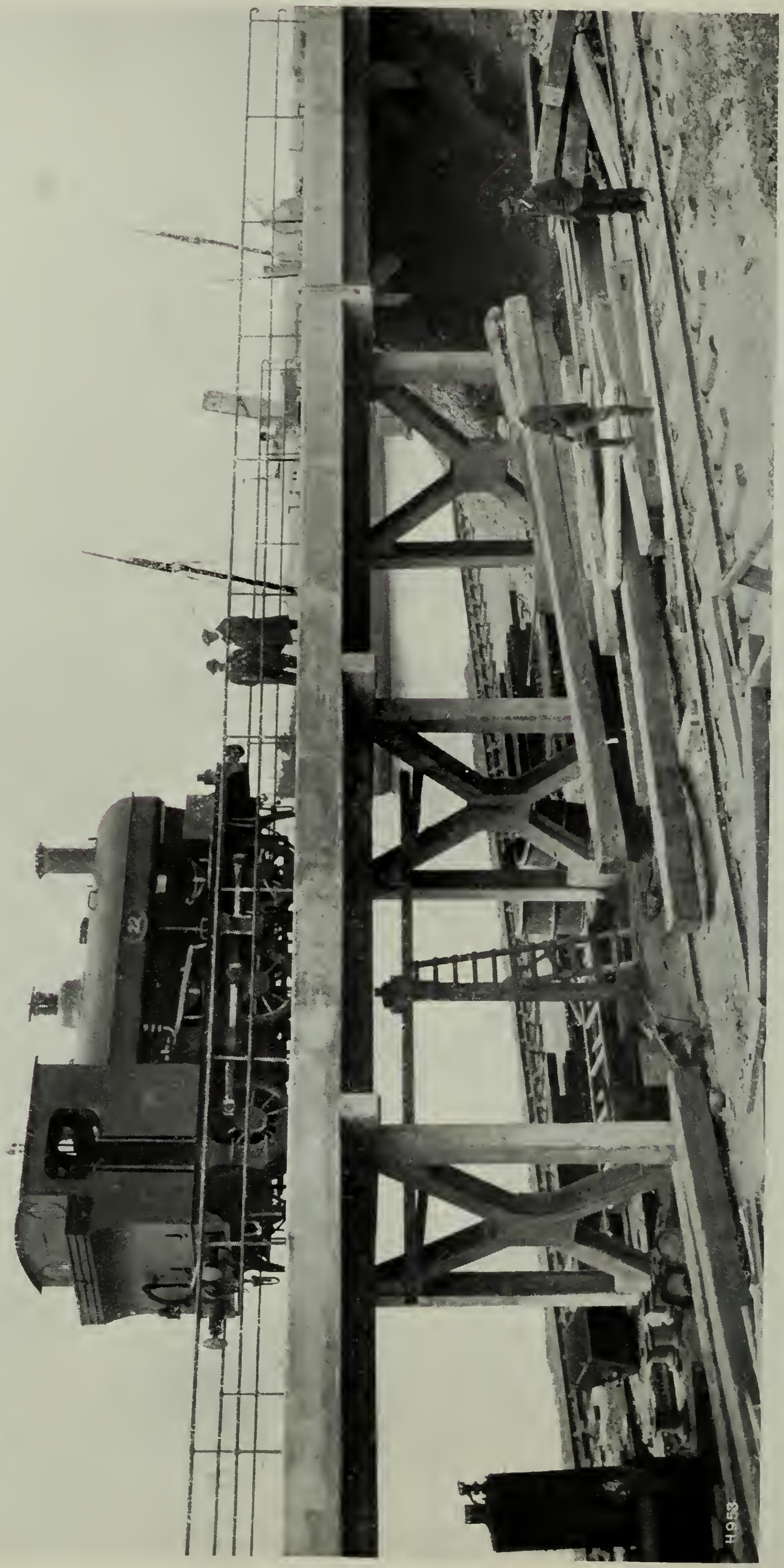
The hoist recently brought into use consists of a 32-ton fixed hydraulic coal tip, constructed by Messrs. Tannett, Walker & Co., of Leeds, and is capable of lifting and tipping a 20-ton standard coal wagon (*i.e.*, a gross load—with cradle—of 32 tons) to a height of 60 ft. above quay level, or about 67 ft. above dock water level.

Among the requirements of modern docks almost the most imperative is speed, and for this purpose the hoist has been arranged to travel, both when



View cf Jetty after a portion of the Test Load was removed.
Reinforced Concrete Jetty and Viaduct at Port Talbot Docks.

lifting and lowering, at the rate of 180 ft. per minute, so that the total highest lift of 60 ft. only takes about 20 seconds, this constituting the fastest speed yet reached with hydraulic power under similar conditions.

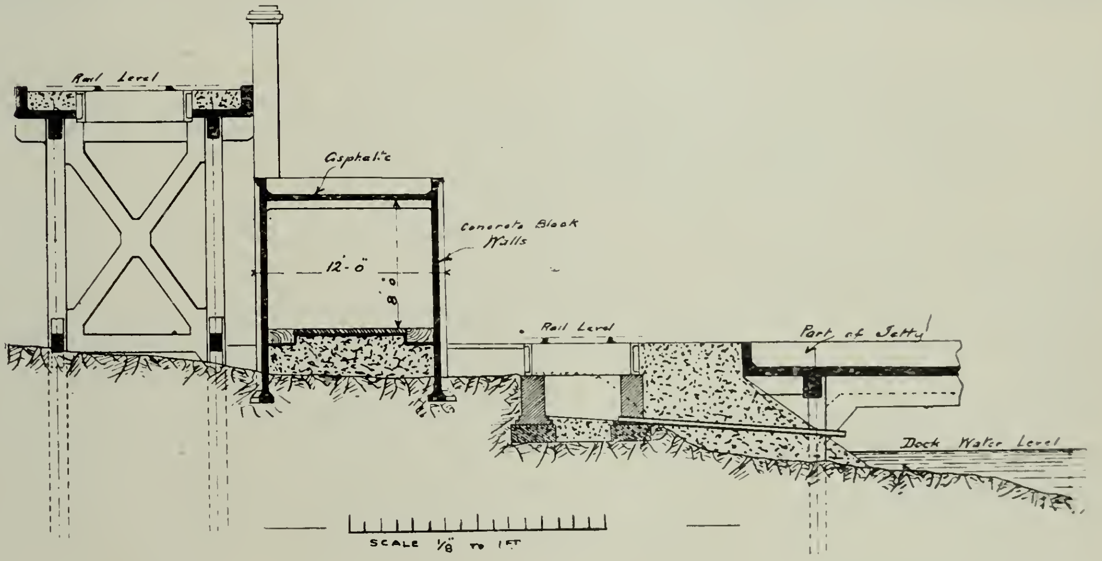


Reinforced Concrete Jetty and Viaduct at Port Talbot Docks,
Test of Viaduct.

The hoist is fitted with two cranes for the handling of anti breakage boxes, etc., capable of raising and lowering 6 tons and 2 tons respectively through a height of 100 ft. at 3 ft. per second to a maximum radius of 30 ft.

The tip shoot is 27 ft. long, 6 ft. wide at the point and 12 ft. at the heel. The heel and the point of the shoot are arranged to be lifted and lowered by independent hydraulic motors. The total height of the tip is about 93 ft. from quay level, exclusive of the anti-breakage crane jibs, which reach about 5 ft. higher.

The loaded wagon sidings for the new tip are capable of storing at least 200 wagons, which gravitate automatically to the tip, and the empty wagon sidings, which are also arranged to gravitate automatically away from the tip, will hold at least 90 wagons. The new storage sidings alongside the tip will hold about 210 wagons.



Cross-sectional view of Weighbridge and House.

Reinforced Concrete Jetty and Viaduct at Port Talbot Docks.

The contractor for the Reinforced Concrete Jetty and Viaduct was Mr. George Palmer, of Neath.

The whole of the embankments, sidings, etc., were constructed by the Dock Company's own men, and the entire works, with the exception of the hydraulic plant, were carried out to the designs and under the supervision of the author.

The hydraulic plant, hoists, etc., were designed and carried out under the supervision of Mr. H. J. Roberts, the Dock Company's Mechanical Engineer.

A TEST ON A FLAT SLAB FLOOR IN A REINFORCED CONCRETE BUILDING.

By ARTHUR R. LORD.

The following account of a very interesting test on a flat slab floor, carried out by Mr. Arthur R. Lord, Research Fellow of the Engineering Experiment Station, University of Illinois, was read by him at a meeting of the National Association of Cement Users of America, and should be carefully studied by our readers.—ED.

The most important recent development in building construction is the introduction and rapid extension of the flat slab type of floor. The advantages of this construction, from the standpoint of both the occupant and the builder, are very generally admitted. It cannot, however, hope to receive the full confidence of engineers until the nature of the structural action in such floors is understood. In the presence of so many unknown conditions as obtain in the flat slab floor, no analysis can stand which is not supported by convincing test data. It is evident that a really satisfactory test of such construction can be carried on in our present laboratories only at a very large expense, and at a sacrifice of many of the conditions obtaining in building construction. We may say certainly that such a test as is practical under laboratory limitations would fail to carry the weight among practising engineers that would attach to a test of an actual structure in which test laboratory methods and refinement prevailed. When we take our laboratory afield, however, we must recognise the disadvantage arising from the fact that the test may not be carried to destruction. In such a test we may hope to secure information on working stresses only, and we may not be able to determine absolutely the weakest points in our design. We shall, however, obtain much data of great value in a hitherto unexplored field, and one of the most important features of the test described in this paper lies in the fact that it demonstrates the feasibility of making field tests with practically laboratory refinement. A test which shows that it is possible to take precise extensometers into a building and measure the actual deformations which occur in the component parts of the structure as the load is applied or removed has justified its undertaking. When the simple transformation of these deformations into stresses has been made, we shall have at hand most valuable information as a basis of future design. Questions regarding the fixidity of the slab at the column capitals, questions as to the extent of " arch " and " slab " action, and the other disturbing elements which separate our analysis assumptions and our actual conditions, are all overcome in the test of the actual structure, and the true stresses present in the floor are observed directly.

The attempt was made to cover a few of the most essential points thoroughly, leaving many other questions for consideration in future tests, when the experience gained in this test may be available for use in determining the best methods. Measurements were taken on the deflection at several points, on the deformation of the steel at the centre of the span, on the deformation of the steel over the column capital, on the deformation of the concrete at the edge of the capital, and on the curvature of the elastic surface in two directions. Working without precedents, it was necessary to design new instruments for use on this test and new methods of attachment for other instruments, so that it must be expected that the accuracy of the results was not so great as may be obtained under the best laboratory conditions. As will be shown, however, the stresses were determined within quite narrow limits, and the difficulties were found less troublesome than had been expected.

The test was made possible through the united action of the Leonard Construction Company of Chicago, the Concrete Steel Products Company of Chicago, and the Engineering Experiment Station of the University of Illinois.

The building tested was an eleven-story and basement warehouse, now under construction at Minneapolis, Minn., for the Deers and Webber Company of that city. *Fig.* 1 shows the floor plan of the building and the location of the panels loaded. The dimensions of the panels are 18 ft. 8 in. by 19 ft. 1 in. A one, two, and four mixture was used, the slab thickness measuring 9$\frac{3}{16}$ in. The floor was designed for a live load of 225 lb. per sq. ft.

The floor tested was the fourth from the ground, and the conditions were not such as to make a high showing of strength. Owing to a failure in the supply of aggregate during the construction of this floor, an abnormal number of bulkhead separations occur in the slab. Such separations occur in every panel under load except one. The concrete was only 40 days old at the beginning of the test. The general conditions were such as to give slightly higher stresses than we would expect were the slab well seasoned and normally poured.

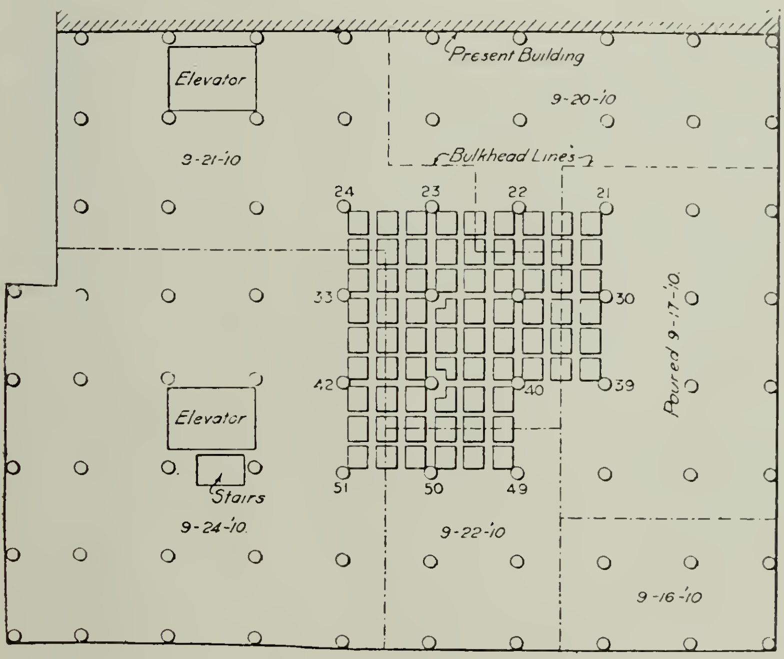


Fig. 1. Plan of Floor showing Location of Panels Tested.

In applying the load, care was taken that no serious arch action in the load be possible. In the earlier stages bricks were piled in piers, as shown in *Fig.* 1, and in the views, *Figs.* 2 and 5, with open aisles from 8 to 16 in. wide between the piers. Later, cement was used as load, the piers being maintained separate as before.

A brief description of the instruments for measuring deformations may be of assistance in understanding the methods used, and in judging the accuracy of the results. For deflection, the instrument shown in *Fig.* 3 was used. A polished steel ball was attached to the ceiling, and another carried on an upright, and the instrument was inserted between them. Measurements were made in this manner to the nearest $\frac{1}{1000}$ in. with accuracy. For measuring the deformation in the steel at the centre of the span, a clamp was rigidly attached to the slab rod (the concrete being removed at one point for this purpose), and a Wissler dial was carried on the clamp (see *Fig.* 4). A fine, silk-covered copper wire was attached to the rod at distance of exactly 15 in. from the clamp, and passed immediately below the rod, over an idler on the clamp, and then over the drum of the dial. This wire was $\frac{1}{16}$ in. below the under surface of the slab rod, and the deformations observed were therefore slightly in excess of the actual deformation in the rod. The wire was placed in this position, because experience in the laboratory has demonstrated that measurements taken below the slab, depending on the position of the neutral axis for corrections, are subject to considerable error. By this arrangement the deformation was measured to an indicated reading of $\frac{1}{5000}$ in. on a gauge length of 15 in. The instrument was less responsive to slight changes than were the other instruments used, and the stress in the steel may vary by as much as 800 to 1,000 lb. per sq. in. from the value observed, which is much closer than we can design for on account of the many unknown factors entering into all design computations.

For measuring the deformation in the steel over the column capital, a modification of the Berry extensometer was made (with the permission of Professor H. C. Berry, of the University of Pennsylvania). This instrument is shown in *Fig.* 5. The slab rods were first bared at two points 15 in. apart, and very small holes drilled in them. The points of the instrument fit into these holes, and any deformation within the 15-in. gauge length is multiplied five times by the lever arrangement before being read on the dial attached to the frame. A slight variation is possible in manipulating this instrument, and five readings were therefore taken at each observation and averaged. The stress is obtained within a range of less than 1,000 lb. per sq. in. A regular Berry 6-in. extensometer was used to measure deformations in the concrete over 6-in. gauge lengths. These observations are reliable certainly to the nearest 50 lb. per sq. in. of stress. To correct for temperature variations, one entire day was spent in observing effects due to temperature alone, and the larger Berry extensometer was read on a standard bar between each series of slab readings. In general, temperature effects were much less serious than were anticipated. In the planning of the tests and the designing of the instruments, the writer was assisted by Professors Arthur N. Talbot and Herbert F. Moore, of the Engineering Experiment Station of the University of Illinois.

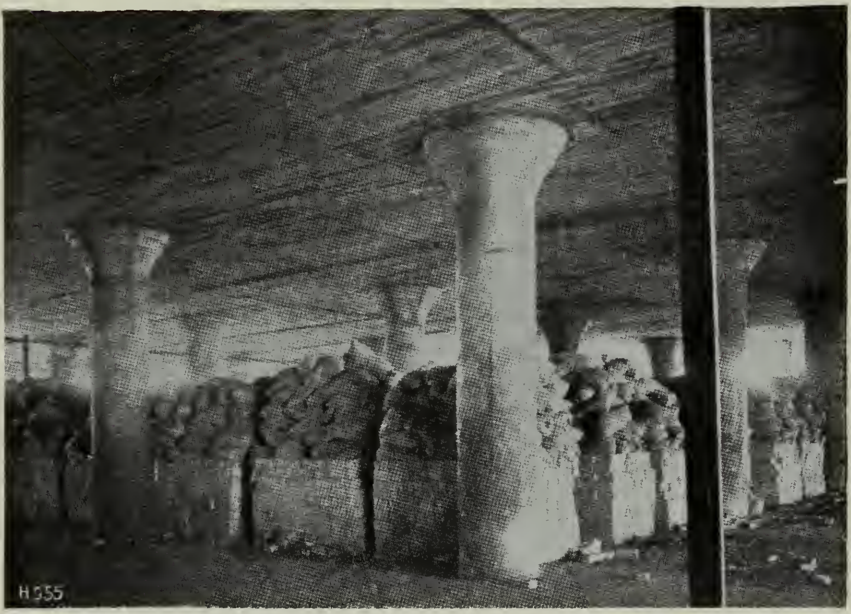


FIG. 2. MANNER OF APPLICATION OF LOAD.

The test continued for six days, from October 30th to November 5th inclusive.

Eight panels were loaded, as shown in *Figs.* 1, 2, and 5. Readings were first taken on all instruments with the floor unloaded, and a load equal to 75 lb. per sq. ft. was then applied over the entire eight panels. Another set of readings were taken, and the load increased to 150 lb. per sq. ft. In this manner alternate readings and loadings were continued for three days. The maximum load of 350 lb. was allowed to remain on floor about 22 hours, reading being taken at frequent intervals during that time. The floor was then unloaded, the outer panels being first cleared, and finally the load was removed from the centre panel. Readings were taken at intervals during the progress of the unloading. The data obtained are plotted in the graphs accompanying this paper.

DATA OBSERVED.

Deflections.—*Fig.* 6 shows graphically the deflections at sixteen points. On the second diagram of *Fig.* 6 note the comparison between readings 5 and 11, where bulkheads existed, and readings 17 and 42, where no bulkheads were present. Other instances of the marked effect of bulkheads on the stiffness of the slab may be seen in the plotted data. In general the deflections were greater in the outer panels than in the centre panel, due in part to the bulkheads in these outer panels and in part to the natural tendency to higher stresses and deflections in end panels. The deflections would probably have been smaller with well-cured concrete, and in considering deflections it must be remembered that this slab was only 43 days old when the maximum load was placed upon it. The maximum deflection found was 0·32 in., exactly $\frac{1}{1000}$th of the span. This was at a bulkhead in an outer panel. In the centre panel the deflection, for all eight panels loaded, was 0·227 in., or $\frac{1}{1400}$ of the span, which increased to 0·274 in. or $\frac{1}{1200}$ of the span, when the load was removed from the outer panels.

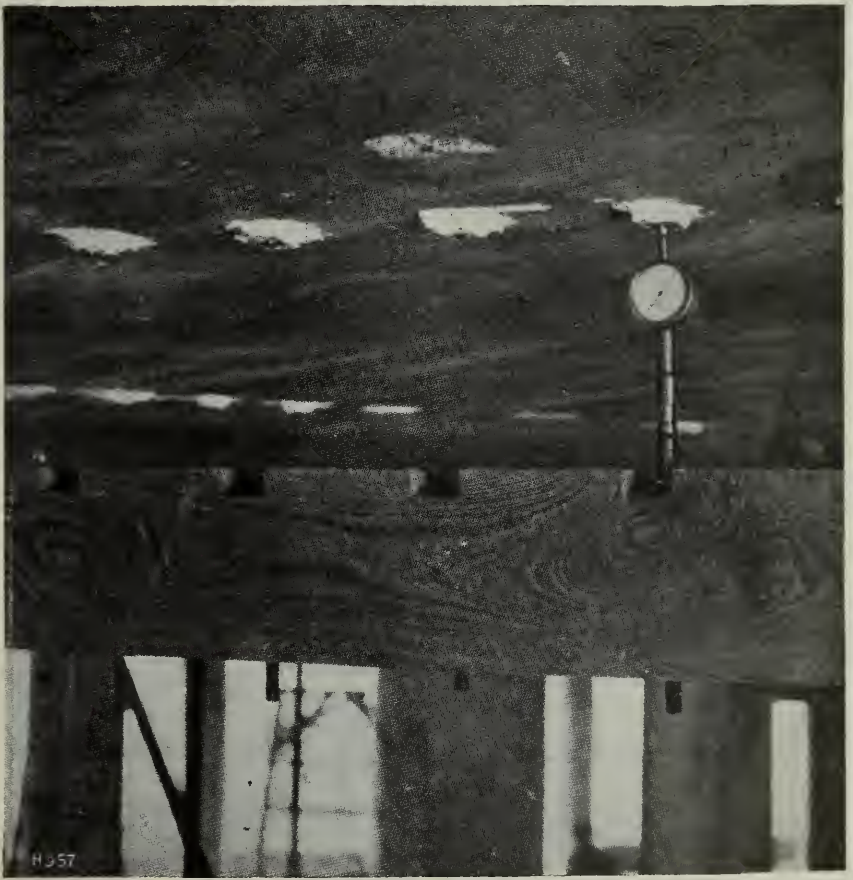


FIG. 3. DEFLECTOMETER IN PLACE.

Stress in Steel at Centre.—*Fig.* 7 give the data on the measured deformations in the steel at the centre of the spans.

The graphs show total deformation over the lengths gauged. On the upper line in *Fig. 7* are shown deformations in the centre panel, and it is to be noted that these are, in general, smaller than those in the outer panels. This would lead us to believe that we should design the steel at the centre of the span for one panel only, as this apparently gives a worse condition *at the centre* than full loading. With reference to *Fig. 7*, it is of interest to point out that all three of these rods were not as high above the decking as the other rods in the band, and hence took a higher stress than the band as a whole. The stresses observed at the centre were very low, and show how marked is the effect of slab action in decreasing the stress at these points. It would seem that any attempt to arrive at the values of these stresses without a liberal allowance being made for this slab action, must result in misrepresenting the actual conditions. The observed stresses indicate that the diagonal and cross band rods take practically the same stress.

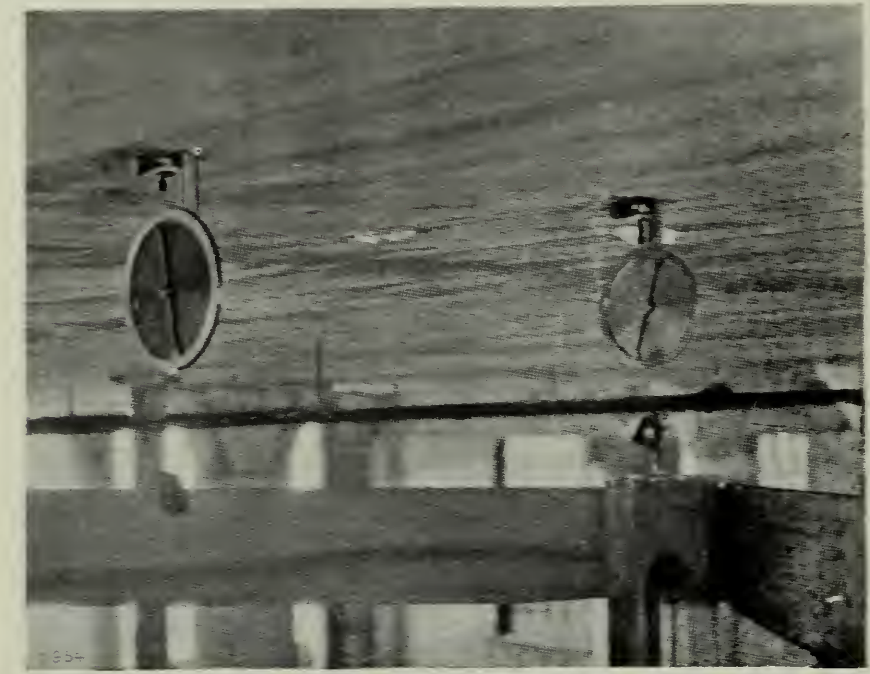


FIG. 4. WISSLER DIAL FOR MEASURING DEFORMATION IN REINFORCEMENT.

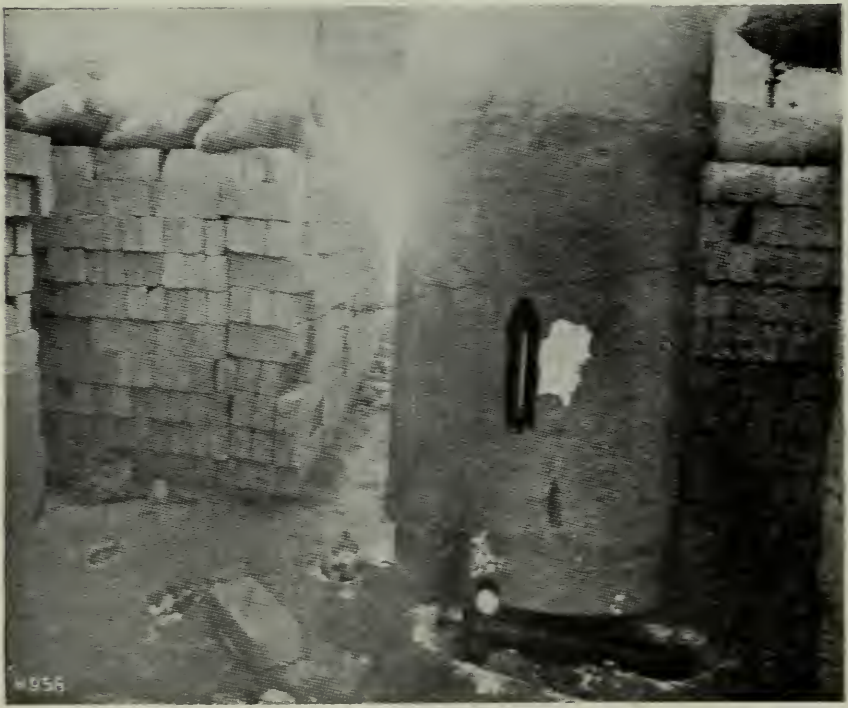


FIG. 5. MODIFIED BERRY EXTENSOMETER IN PLACE FOR MEASURING DEFORMATION IN REINFORCEMENT OVER CAPITAL.

Stress in Steel over Head.—*Fig. 8* gives the data on this subject. The upper row are diagonal rods, the lower row cross-band rods. Note that rods 205 and 208, which are outer rods in the cross-bands, took much higher stresses than rods 206 and 209, which were near the centre of the band. In the writer's opinion this is strong evidence against the assertion commonly made that these outer rods serve only to carry load to the rods which they intersect and which do pass over the column. Among the diagonal rods we may note that the stress in rod 207 was measured over the edge of the capital while that in 203 and 204 was measured opposite the centre of the column. The higher stress in 207 would seem to indicate that the stress in these rods decreases as we pass from the critical section at the edge of the capital to any section nearer the centre of the column. This is as we should expect. The stresses found from these readings indicate clearly that the slab should be designed for a maximum moment over the support, and not at the centre as is quite commonly

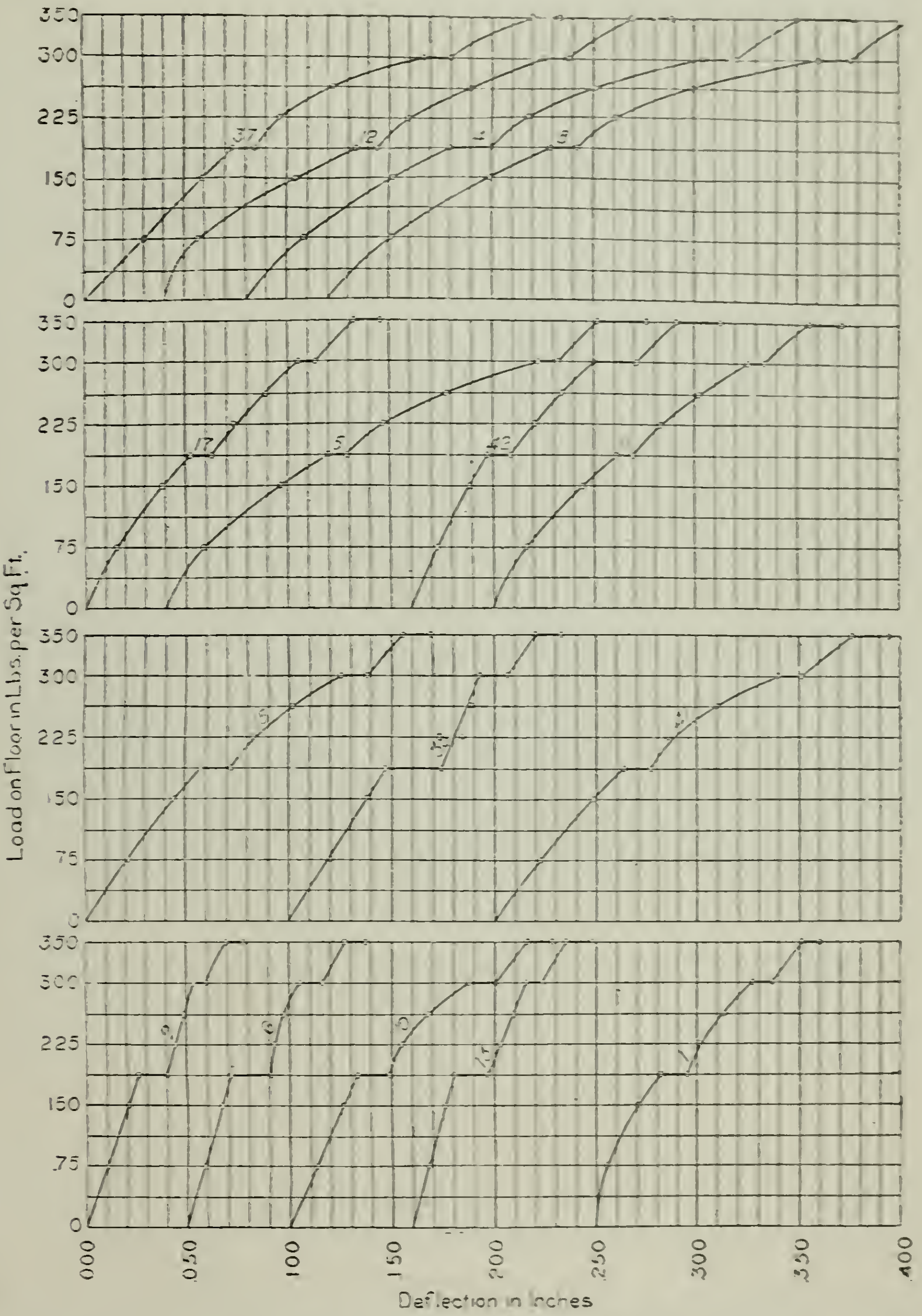


Fig. 6. Diagram of Deflections.

maintained. In the design of this building some 75 per cent. more steel was provided over the support than was used at the centre, and we easily imagine that the stress must be exceedingly high in many flat slab designs where this extra steel is not provided in anywhere near the same amount. Since the stress reached the allowable value of 16,000 pounds per sq. in., we may conclude that the designers were not at fault in providing this additional steel over the support.

Stress in Concrete at Edge of Capital.—*Fig.* 9 gives deformations observed in the concrete. Owing to the fact that no intention of testing existed when the slab was poured no specimens of the concrete were available from which to determine the modulus of elasticity. Hence we are obliged to assume a value for concrete about 40 to 45 days old cured in fall weather at Minneapolis. From experiments made at the University of Illinois, concrete of the same age cured under laboratory conditions showed a modulus of 1,875,000 pounds per sq. in., and in Table I. this value has been used as giving the very highest possible value for the concrete stress. It would probably be fairer to the construction to use a modulus of 1.500,000 pounds

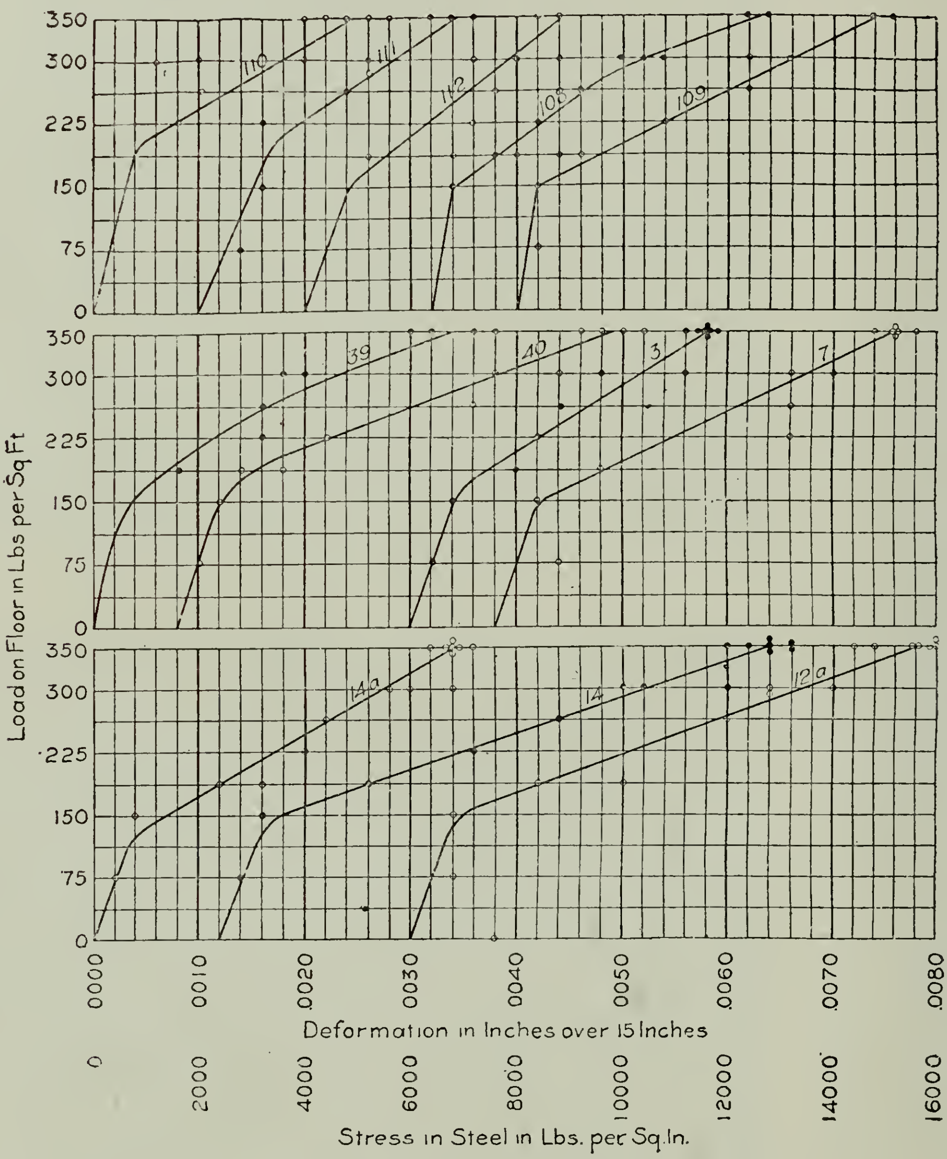


FIG. 7. DIAGRAM SHOWING STRESS IN REINFORCEMENT AT CENTRE OF SPAN.

per sq. in., resulting in stresses four-fifths as large. In *Fig.* 9 a stress of 100 pounds per sq. in. corresponds to a deformation of .0004 in. with a modulus of 1,875,000, or to a deformation of .0005 in. with a modulus of 1,500,000. An interesting feature shown in the curves is the falling off in the concrete stress when the load was allowed to remain over night. The decrease is less marked at higher loads than at low loads, while readings taken at very frequent intervals while the maximum load was on the floor showed that at first the stress steadily increased, and the decrease did not begin until some time after the load was applied. The phenomenon is of interest as showing the readjustment in stresses which takes place under load even in the least plastic constructions. In general the concrete stresses checked those found in the steel over the support. It would not seem that compressive reinforcement were needed at this point, the maximum stress being from 650 to 750 pounds per square in., which is permissible for concrete stressed in several directions and over a very short distance.

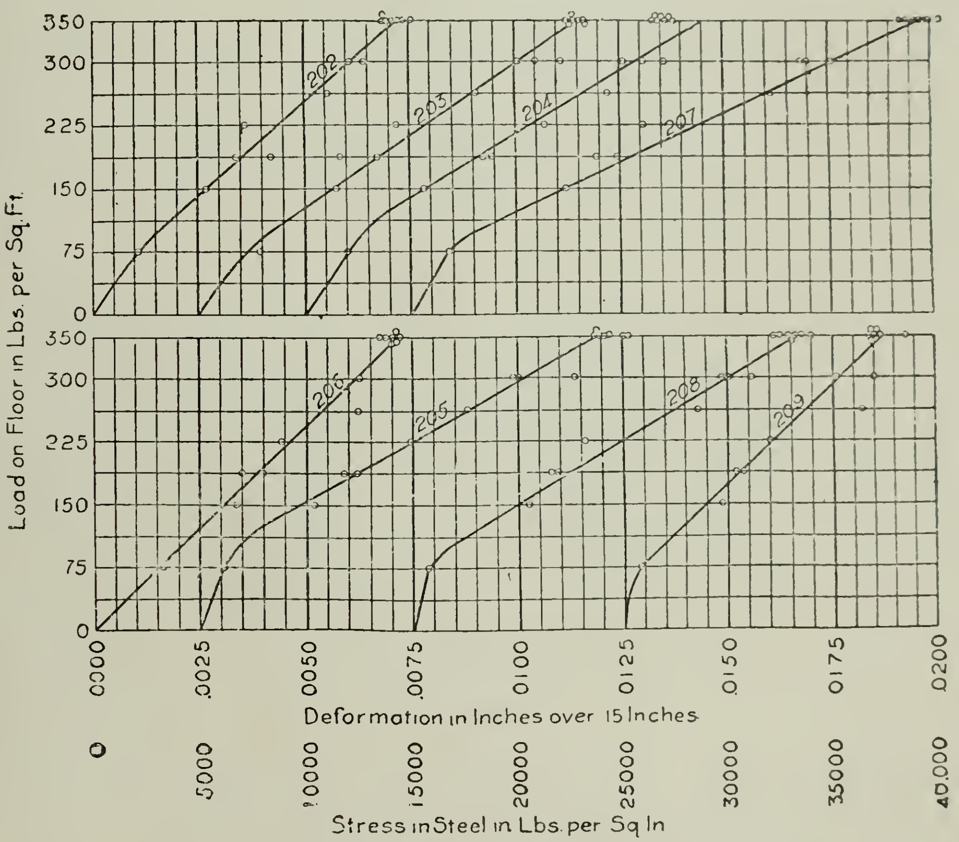


FIG. 8. DIAGRAM SHOWING STRESS IN REINFORCEMENT OVER CAPITAL.

If, however, a higher percentage* of steel had been used, resulting in a thinner slab, as is commonly done, it is evident that compressive reinforcement would be absolutely necessary for good design.

Summary of Stresses.—Table I. gives a summary of the stresses found at various points under the design load of 225 lb. per sq. ft., and also under the maximum load applied of 350 lb. per sq. ft. In every case where a choice has been possible the higher value has been given, as, for instance, in the concrete stresses the modulus has been assumed as 1,875,000 lb. per sq. in. instead of the (probably) more just value of 1,500,000 lb. per sq. in. The dead load stresses have been taken as one half the live load stress at the design load (the dead weight of the slab being half this load). This, also, is a maximum assumption, and probably somewhat in excess of the true value, as the concrete was not broken in tension until after a live load of 75 lb. per sq. ft. was applied, and the tension in the concrete will undoubtedly account for a much higher percentage of the dead weight than of the live load.

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* In the slab tested a very low percentage of steel was used, giving a much thicker slab and hence better stress conditions at the support than is usually found in this type of construction.

Cracks.—Very careful observations were taken to discover and record all cracks. A powerful reading glass was used to aid the eye, and dust was removed by means of bellows. It is exceedingly easy *not* to discover cracks in such a test, and an ordinary observer would very likely have been aware of the existence of but few of these cracks. At a load of 262·5 lb. per sq. ft. a crack was observed at the bulkhead, where two days had elapsed between the pouring of the adjacent floor sections. At 300 lb. per sq. ft. cracks appeared at the other bulkheads. Suggestions of cracks were also found in the centre panel where no bulkhead existed, and over the edge of the capital, these being very faint and hard to trace for any distance. The cracks about the column head are of interest as indicating the position of the critical section for which moments should be figured in analyses. These averaged about two or three inches outside the edge of the capital below. At one of the columns the position of the crack would seem to indicate that for a single panel loaded the critical section moves nearer the support resulting in higher stresses at the centre. This crack and similar ones were very faint, indicating a lower stress in the steel over the support at such points. The cracks shown running diagonally near columns were in all cases directly beneath slab rods. Another set of cracks which developed only under the maximum load of 350 lb. per sq. ft. possesses a peculiar significance. These cracks ran along the centre of the cross-bands, being easily traced at the centre, growing fainter towards the columns, and disappearing entirely in most cases before reaching the crack over the edge of the capital. These cracks afford a most satisfactory evidence of the presence of " slab action," and would be expected to occur if Professor Talbot's theory of such action is accepted. These cracks have, we believe, never been observed before, probably because other building tests have not been extensive enough to develop them to a marked degree, and because cracks have not ordinarily been very carefully observed.

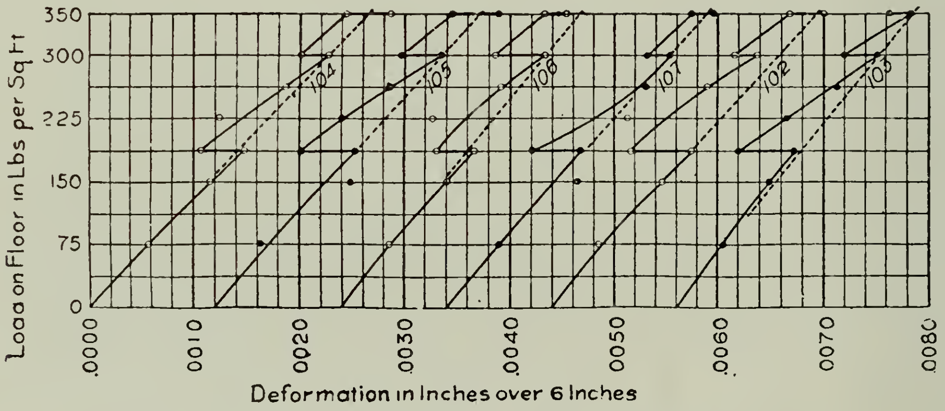


FIG. 9. DIAGRAM SHOWING STRESS IN CONCRETE AT EDGE OF CAPITAL.

GENERAL CONCLUSIONS.

The most important result of the test, in the writer's opinion, lies in the demonstration that well equipped laboratories may undertake such tests with the reasonable expectation of securing reliable and useful data. The difficulties to be met are not greater than those encountered in experimental work in the laboratory. It is not believed, however, that inexperienced men would be warranted in undertaking such a test as the instruments used require the handling of trained observers.

The test indicates positively that moments are much greater at the support than at the centre of the span.

It indicates, by the position of the cracks, the section for which moments should be calculated at the support.

It also indicates that the stresses at the centre of the span are much lower than the computed stresses at this point would lead us to expect.

It indicates that bulkheads act to increase deflections and stresses.

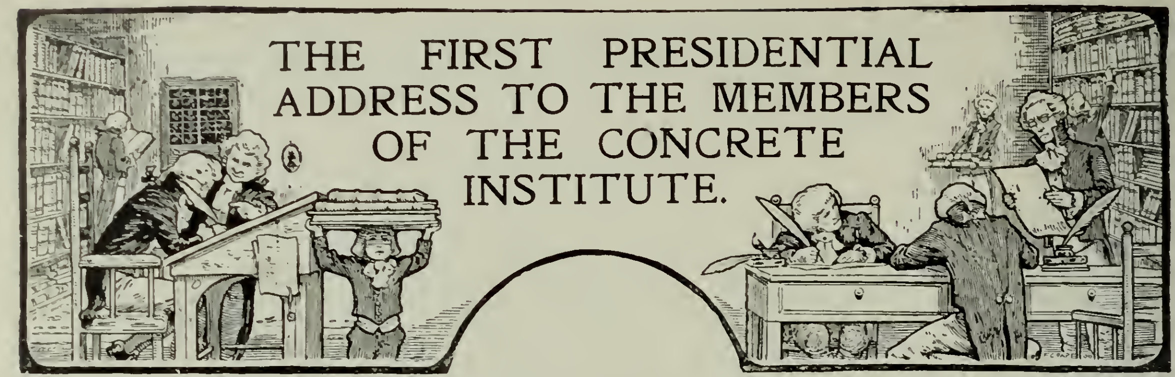
The test shows that the design of this particular building is well balanced, and that the stresses are safe. It may be that a slightly greater amount of steel could be advantageously placed over the column head in order to reduce the stress at this point somewhat below 16,000 sq. in. and make some additional allowance for irregularities in the actual execution of the design. It does indicate, however, that serious questions may be entertained as to the stresses in many buildings of this type where higher percentages of steel have been used and very little additional strength provided at the support.

It indicates that the steel *at the centre* receives its maximum stress for the condition of one panel only loaded.

Table I.—Summary of Stresses.

	Design Load, 225 sq. in.			Maximum Load, 350 sq. in.		
——	L.L.	D.L.	Total.	L.L.	D.L.	Total.
Steel Over Head :						
Diagonal, Maximum ...	13,800	6,900	20,700	24,200	6,900	31,100
Band, Average	11,000	5,500	16,500	18,800	5,500	24,300
Cross, Maximum ...	10,000	5,000	15,000	18,800	5,000	23,800
Band, Average	9,000	4,500	13,500	17,200	4,500	21,700
Steel at Centre :						
Diagonal, Maximum ...	2,400	1,200	3,600	4,800	1,200	6,000
Band, Average	2,000	1,000	3,000	4,800	1,000	5,800
Cross, Maximum ...	2,800	1,400	4,200	8,000	1,400	9,400
Band, Average	2,500	1,300	3,800	6,600	1,300	7,900
Outer, Maximum ...	4,600	2,300	6,900	10,400	2,300	12,700
Panels, Average ...	3,800	1,900	5,700	8,000	1,900	9,900
Concrete at Capital :						
Diagonal, Maximum ...	530	265	795	800	265	1,065
Direction, Average ...	500	250	750	750	250	1,000
Cross, Maximum ...	500	250	750	800	265	1,065
Direction, Average ...	468	234	700	750	250	1,000

Concrete stresses based on $E_c = 1,875,000$ lb. per sq. in.



THE FIRST PRESIDENTIAL ADDRESS TO THE MEMBERS OF THE CONCRETE INSTITUTE.

We give below Sir Henry Tanner's Presidential Address, which is highly interesting in its reference to the general aspects of concrete and reinforced concrete, and which claims the closest possible attention. It was read at a meeting devoted solely to this address and was naturally not made the subject of discussion, the remarks of members being limited to a vote of thanks, which was proposed and seconded by two of the Vice-Presidents. The attendance was a moderate one, comprising members, but no distinguished visitors were present. The view was expressed on several sides that the Presidential Address might have been made the subject of discussion, but we are pleased to note that the precedence of the R.I.B.A. and similar senior bodies was followed.—ED.

SIR HENRY TANNER'S ADDRESS.

THE Concrete Institute has now been in existence some three and a half years, and as this is the first presidential address it is a fitting opportunity for reviewing the work done during that period.

As you are aware, it came into being at a luncheon given by Mr. Edwin O. Sachs at the Ritz Hotel in July, 1908, and the necessary regulations which had been prepared were agreed to, and the Earl of Plymouth was elected first President. Mr. Sachs is to be congratulated in so effectively organising a new Society.

Under the regulations referred to the Council felt that they had very little power over the proceedings of the Institute, that power really resting with the Executive, and eventually the reconstruction of the Institute on similar lines to those of other institutions of a like character came about. At the time of the change the number of members was 881, which must be considered as quite good. It is now about 875.

Less interest, however, appears to be taken in the papers read and discussions thereon than was formerly the case, while it becomes increasingly difficult to obtain papers which are at once suitable and of sufficient interest. It is desirable, therefore, that the causes which give rise to this state of things should be inquired into and remedied. I am aware that this is not the only institute which is forced to make similar admissions, but this is a young institute, and there should be abundant energy in it.

These matters have been discussed by your Council, which at its last meeting appointed a Committee to consider and report how the Institute could best be broadened in its scope and interest and in its usefulness to members.

STRUCTURAL ENGINEERING.

Concrete and reinforced concrete form parts only of structures; frequently there is much steelwork and other materials involved, including heavy timbering, either permanent or in false work.

It is considered, therefore, that structural engineering being so intimately connected with our special subject might well be regarded as coming within our purview, and that papers on such matters should be read and discussed. This is particularly the case, having regard to the large number of engineering members. This can be done without in any way intrenching on the prerogative of other societies, as there is no institute dealing particularly with such subjects.

The Committee is empowered to take energetic steps to foster the structural engineering side, and thus we see how in future we shall in effect be not only a Concrete Institute but an Institution of Structural Engineers as well.

In this connection I cannot but think that membership requires better classification and could usefully be re-arranged on the lines of several of the engineering societies, and the Committee might well consider the point. There might, for instance, be Members, Associate Members, Honorary Members, Associates and Students. In the future, also, it may be possible and advisable for us to hold an examination in advanced structural engineering, which shall in no way intrench upon the examinations of other bodies, but be supplemental thereto.

Further, I think that much more use might be made of the *Transactions*. Many members and others must be in possession of information which would be of the greatest value to their brethren. The *Transactions* should be issued regularly at intervals not exceeding three months.

Next I wish to draw attention to the small attendance at the meetings. We can hardly hope that gentlemen will come forward to read papers, to open discussion, etc., unless they can rely on an audience of a reasonable number of people, and, with one or two exceptions, the meetings this year were certainly not of that character.

The Annual Dinner was a success, we obtained the numbers expected, and I was supported, among others, by the Presidents of the Institution of Civil Engineers, the Royal Sanitary Institute, and the Surveyors' Institution. Apart from this, the attendances at the Summer Meeting were not altogether successful.

INSTITUTION OF CIVIL ENGINEERS AND REINFORCED CONCRETE.

I am pleased to be able to say that the Institution of Civil Engineers has taken up the subject of reinforced concrete through the Committee which it appointed some time ago, and to which my name was added in June of last year, and a considerable sum of money has been devoted to experiments which are in process of being carried out, and I hope for much advantage from what I may regard as the co-operation of that Institution. There is no doubt that experiments are needed in this country with a view to obtain a consistent and complete series based on materials to be obtained here and mixed and tested under similar conditions. At the present time we have to rely on experiments in America, Germany and France with cement of varying character and local aggregate, and it would be of the greatest advantage if these could be repeated in some cases at intervals for some years, the improvement in strength being so great.

THE JOINT COMMITTEE'S REPORT.

For some time past the Joint Committee appointed by the Royal Institute of British Architects, upon which we are represented, has had under consideration the revision of its first report, and the revised edition was published several months ago. It is satisfactory to think that this report, so far as it goes, is accepted generally as the basis of local regulations for governing buildings of this character. These regulations require to be framed in such a way that they can be amended in order to keep pace with the acquisition of fuller and more complete knowledge, which will no doubt come in due time. The importance of being able to do this is shown by its having been necessary for the London County Council to obtain an Act of Parliament in order to make such alterations and additions to its Building Act to admit of reinforced concrete being used in an adequate way, and so advancing the development of a method of construction which has been proceeding in America and on the Continent at a pace considerably in advance of this country and at a saving of much money, while under suitable conditions it is a far better method of construction to adopt for safety, as, for instance, in the case of countries liable to seismic disturbances.

BUILDING REGULATIONS.

However, with the approval by the Local Government Board of the London County Council by-laws, after submission to several societies, including ourselves, for observations, it may be expected that there will be a considerable extension in the use of reinforced concrete in London, as also in other parts of the country. Other cities have also taken steps to admit of such methods of construction being used, and it may be hoped that the list may be much extended beyond Newquay, which the Local Government Board quoted as being the only place the building regulations of which specifically admitted of the use of reinforced concrete. Suitable by-laws to this effect remain to be added to the model code.

The preparation of such reports and the adoption of by-laws regulating the use of reinforced concrete must tend to standardisation in design, and this must prove good. We have fortunately been fairly free from any serious failures in reinforced concrete construction, but experiences in America and on the Continent show that there is need for watchfulness. Although most of the failures have been attributed to bad construction and the ignorance or carelessness of contractors and their employees, cutting in design may have been a contributory cause.

THE COST OF SCHOOL BUILDINGS.

The Board of Education appointed a Committee to inquire into the question of economy in building and as to whether buildings of a more temporary nature could not very well be brought into use. Reinforced concrete came in for its share of the discussion, but the estimates of cost varied largely, from 33 per cent. less to 10 per cent. more than for ordinary building. It seemed to me that witnesses having a more intimate knowledge of the cost of such buildings might have been called, while it should be possible to standardise such buildings. No difference of locality will account for these variations. A loan period of thirty years was referred to, while the usual loan period for schools of ordinary construction was stated to be fifty years. It is impossible to understand the difference in treatment. It is very little good encouraging specific proposals for the use of novel materials or methods for public elementary schools when such differences of treatment prevails, and in effect penalise any new system of building, while local by-laws make no special provision proper to the use of reinforced concrete.

LECTURES ON REINFORCED CONCRETE.

The Council inaugurated a series of lectures of an elementary character given by Mr. R. W. Vawdrey during the spring, which were fairly well attended, but we can scarcely hope to effect much good in competition with the courses given at the London County Council schools and under the auspices of the London and other Universities, which have the advantage of testing apparatus, etc., and are generally better equipped. This is a matter worthy of the consideration of the Council.

STANDARD NOTATION.

The Standing Committees of the Institute have done good service; the new notation appears likely to be adopted generally in English-speaking countries, and its adoption is now being considered in America with reasonable hopes of success. This must be regarded as very satisfactory. We have already intimated that we shall be happy to co-operate with the American Joint Committee in endeavouring to arrive at some common notation for English-speaking countries, the basis being that it shall be mnemonic, the symbols coinciding with the initials of the chief words in the terminology of the subject.

Our Committees have also submitted reports on the Standardisation of Drawings and the Testing of Concrete, Reinforced Concrete and Materials employed therein, both of which are to be discussed at meetings to be held early in the ensuing session.

TENDERS FOR REINFORCED CONCRETE.

Useful papers have been read before the Institute during the past sessions, and among those of last session that read by Mr. R. W. Vawdrey on "The Dissociation of Competitive Designs and Tenders" is one of much interest to many. The methods adopted for obtaining tenders are various, but it is seldom that tenders including design are asked for in any other branch of building than that of reinforced concrete. It is true that as a rule the general scheme is laid out by architects, and the reinforced-concrete designer has only to deal with the sizes of beams and columns, thicknesses of slabs and their reinforcement, but even this involves a very large amount of work where repeated by a number of persons or firms, and it has to be remembered that quantities have to be prepared by the specialist, one reason being because the drawings are so incomplete that it would be impossible for anyone else to prepare them. In the circumstances the quantities must be to some extent conjectural, a most objectionable state of things. Such quantities should, of course, be prepared from completed drawings and by an ordinary surveyor, as in the case of other processes of building, if competition is to be fair and on equal terms. The responsibility for their accuracy, however, lies between the specialist and the contractor, but the tendency is for any deficiency to be saved in some way, as, of course, in the case of keen competition there can be no margin to provide for such contingencies. With the architect's plans to work on there seems to be little opening for much variation when the R.I.B.A. rules have to be applied, nevertheless there results very considerable divergence in the amount of the tenders submitted on such conditions, and this would seem to be due partly to the ordinary differences in builders' tenders and partly to the quantities of work to be done, of which there may be a dozen different sets. This plan avoids the selection of a specialist who is probably interested in some system and more or less indefinite patent, but it involves the employment of an expert to check the specialist, while the method affords open competition for the design and limited competition for the carrying out of the work. From an architect's and from a surveyor's point of view the method is not satisfactory, and it prevents consultation and co-operation between the architect and specialist, which, to my mind, is essential to a proper arrangement and to the efficiency of the building and the best disposition of materials. Competition for design and construction must involve the utmost economy, which may, perhaps, be carried to the verge of safety, otherwise there is very little prospect of the work being obtained, with the result that the labour involved is almost certainly thrown away. Economy in first cost appeals to most people, but there are other points to be considered, such as efficiency and the avoidance of unnecessary risks. The specialists, however, have the whole matter in their hands, and it is of no use theorising while they submit their designs and tenders, or, rather, the builders do so for them on the mere chance of obtaining the work.

Competition in reinforced concrete work has now proceeded to inordinate lengths, and it would seem that we have obtained the chief advantage to be derived from competition in design, and that steps should be taken to put some limit to it. To effect this, designers must be placed more in the position of consultants, and not so closely associated with contracting firms as has hitherto been the case. The disappearance of patent royalties and licences will no doubt facilitate the change.

ARCHITECTURAL TREATMENT OF CONCRETE.

Much is said about the architectural treatment of concrete, and that that treatment should be appropriate to the material. The great desire is to make the whole building of reinforced concrete, including the external walls, and developing some new method of architectural treatment. There are many opportunities for this, as in isolated structures where various methods of surface treatment may be adopted, but in town streets it is doubtful whether anything but stone or brick front elevations will satisfy building owners or ground landlords. It seems equally logical to apply a stone or brick front to a reinforced-concrete structure as to an ordinary steel-framed and concrete one.

FUTURE OF THE INSTITUTE.

The Institute has a strong Council and an energetic Secretary, who are anxious that the Institute should take its proper place in the scientific world. In the Press it has been stated that " the time has now arrived when the serious and long-required technical and practical assistance to be expected of an institution of this kind should be rendered to those who are entrusted either with the design or with the execution of works in concrete and reinforced concrete " ; and that, " if the Institute in its next few years does sound scientific and practical work on the broadest lines . . . its success is assured, and that a very large amount of useful work is expected during the impending session, while papers are desired of greater technical interest than those presented during the past year." The Council has devoted itself to meeting the wants expressed above, and is, to some extent, fully alive to the necessity of obtaining good papers.

It may be thought that my remarks have a pessimistic tendency, but that is not intended, my desire being to urge all our members to take what part they can in the work of the Institute for the benefit of all. With the extension of our scope to include Structural Engineering in its broad aspect we shall have a wider outlook and a future of great usefulness, with a possibility of a considerable increase in membership. I therefore conclude with feelings of the most optimistic character.

THE VOTE OF THANKS.

Mr. Edwin O. Sachs, F.R.S.Ed. ***(Vice-President)***, in proposing a vote of thanks for Sir Henry Tanner's presidential address, the first address of its kind given in the Institution, said he thought the members could congratulate themselves on having had such an interesting address, covering a vast field in a most interesting manner, and containing a very large amount of useful information and a number of very useful hints.

Generally.—Sir Henry, at the close of his address, had suggested that it might be regarded as being in a slightly pessimistic vein, but had nevertheless emphasised the fact that he looked optimistically into the future.

He (Mr. Sachs) was personally somewhat of an optimist, and though that little child, the Concrete Institute, was now going through its "children's diseases" of the "measles" and "scarlet fever," and so on, he was sure, when it had recovered from those youthful ailments, it would grow up to be that strong and important and influential individual which many a man, to make the comparison, was to-day who had survived a somewhat "delicate" childhood.

Some Successes.—Being an optimist, he liked to dwell on Sir Henry Tanner's points which spoke of the recent successes of the Institute. Its greatest success during the last two years was, perhaps, its First Annual Dinner. That, at any rate, was really a great success for a young institution. It was well managed, it went well, the speeches were interesting, and altogether it was a success, and as an institute, they must give their very best thanks to Sir Henry Tanner for having personally arranged the dinner. If that might be taken as an example of what could be done by individual effort, he was sure that, if a great deal of individual effort were placed into the working of the Council, they would have numerous successes of that description.

They ought also to congratulate themselves that Sir Henry Tanner had been elected on the Institution of Civil Engineers Reinforced Concrete Committee. It was an honour to the young Concrete Institute to have so able a representative there, and it was a very great step to think that the Institution of Civil Engineers, who in the earlier days of reinforced concrete, say in 1908, ignored the subject, in this year, 1911, not only had such a Committee at all and the Concrete Institute's President serving on it, but that they were actually represented at the Institute Dinner by their President.

It was a matter of congratulation also that this year they had representatives on the Joint Committee on Reinforced Concrete organised by the Royal Institute of British Architects; and there, again, they had the pleasure of knowing that their President was the Chairman of that Reinforced Concrete Committee, which had done such very good work.

Another point for congratulation was that they made a start with the elementary educational lectures of Mr. Vaudrey. They were most able lectures, and deserved far more support; and if similar experiments were repeated he was sure they would find favour.

The last point which he would mention in the congratulatory vein was that the standard notation—rather an obtuse subject—to which they had devoted a considerable amount of time, was pleasing their American friends, and they were at least half-way to some understanding as to a notation that was mutual to this side of the Atlantic and the other.

Marking Time.—In the matter of membership, and in certain other directions, they had perhaps been marking time, but that did not matter greatly, because they had been going rather fast in certain directions. It was very seldom that an institute which was not two years old, as was the case when he (Mr. Sachs) ceased to actively conduct its affairs in 1909—was mentioned in an Act of Parliament as an authority to be referred to on questions of regulations. The Concrete Institute had already in 1909 secured a standard which was quite that of many an older institution, and marking time was not necessarily an evil. There had been some administrative changes to make, and those administrative changes took time. Nothing better, however, could be said than what Sir Henry Tanner said in the latter part of his address, that, now the administrative changes had been completed, they should get to work, and do still more and better service for the science of concrete in the future. He (Mr. Sachs) hoped that advice would be followed.

Inadvisability of Changes.—Personally, he would refrain, concluded Mr. Sachs, from touching on the question of the inclusion of structural engineering in the subjects to be dealt with by the Institute. He had views on the matter, but they were not suitable for the meeting of that particular night, and the only thing he wished to say emphatically was that, having devoted such a considerable time to administrative changes, he hoped the coming year of the Institute would be mainly devoted to constructive and effective work, rather than to any further timestaking reorganisation of their constitution.

They had to congratulate themselves on having Sir Henry Tanner as President. They had also to thank him for his very able presidential address, and no better recognition could be given than by according him a very hearty vote of thanks, and wishing him a most successful year of office.

Mr. Alexander Ross, M.Inst.C.E. ***(Vice-President),*** in seconding the vote of thanks, said Sir Henry had done a great deal for the Institute, and had nursed it from the first, and had never failed them, or in any way been afraid of carrying out work and labour towards its progress.

Generally.—The Institute had, as a matter of fact, made decided progress since its initiation. It was comparatively new, and, as had been said, very few institutions at the same age stood so well before the public and before the profession.

Caution as to Changes.—That being so, they must be very careful before bringing about any revolutionary changes in its constitution or objects. Once it was overwhelmingly decided that changes were undoubtedly right, then, of course, they might be made, but they should be very certain that they were on the right lines before moving.

Sir Henry had necessarily spoken rather in a minor key. The membership had not gone up so rapidly of late as it ought to have done, and the meetings had not been so well attended as they might have been, but there was one great essential fact: many of the papers had been very good.

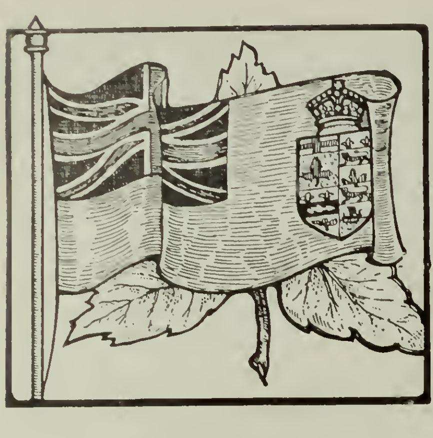
Meetings and Discussions.—It had always struck him that possibly the endeavour to listen to an excellent paper and discuss it all in one night was more than they ought to expect. Probably it might be an improvement to fix the length of the meeting, and carry on discussions as other societies did night after night until the subject had been thoroughly exhausted. Such a course secured that the meeting should not become tedious in any way, and everyone knew exactly when to close; and then there was the other advantage, that a period of a week or more intervened in which those who took an interest in the subject could look it up and come next night prepared to give a thoroughly good account of themselves in discussing it.

Nothing could be said on the address except in its favour and in praise of it, and he had much pleasure in seconding the motion for a hearty vote of thanks to the President.

Mr. Sachs then put the motion to the meeting, and it was carried amid loud applause.

The President (Sir Henry Tanner, C.B.), in returning thanks for the vote, said he feared his remarks had been rather short, but perhaps they had some pith in them. At all events, he was very anxious that the whole of the members of the Institute should see where they were, and understand really where improvement was wanted. He hoped what he had said might produce better meetings, which would be more satisfactory to the people who delivered lectures.

It was announced that the next ordinary meeting would be held on December 14th, when G. C. Workman would give a paper on "Some Recent Works in Reinforced Concrete."



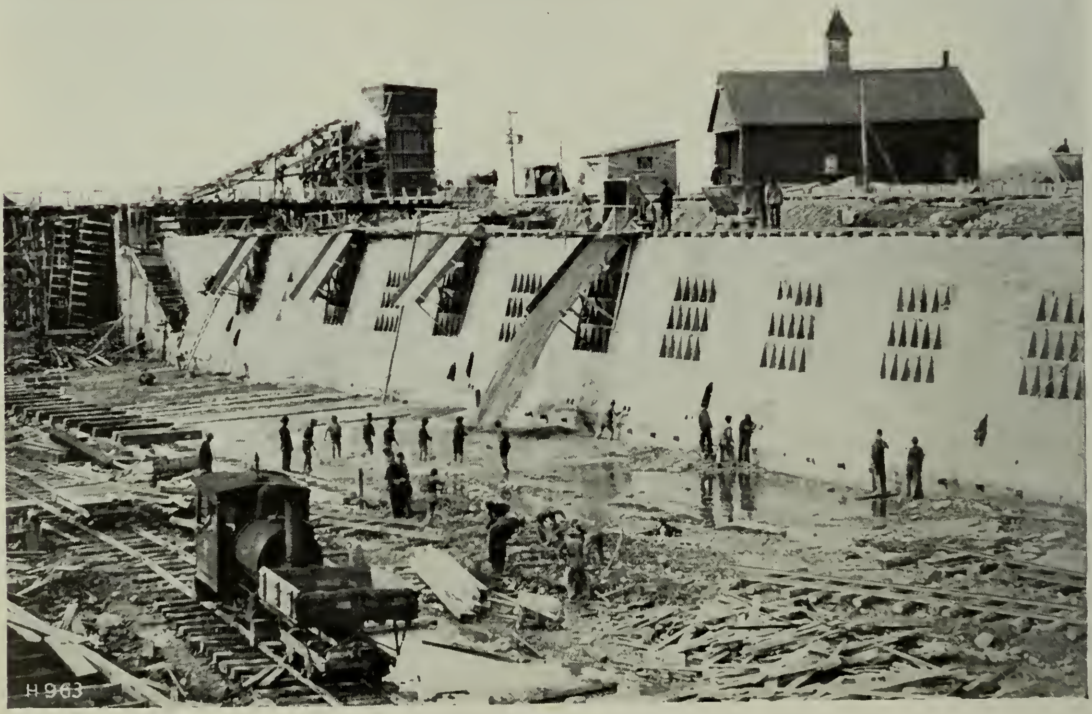
SOME EXAMPLES OF CONCRETE WORK IN CANADA.

We are very pleased to note the rapid strides which reinforced concrete is making in Canada, and in this article we are describing several structures erected there of this material, and hope, at a later date, to give further examples.—ED.

DRY DOCK CONSTRUCTION AT PORT ARTHUR, ONTARIO.

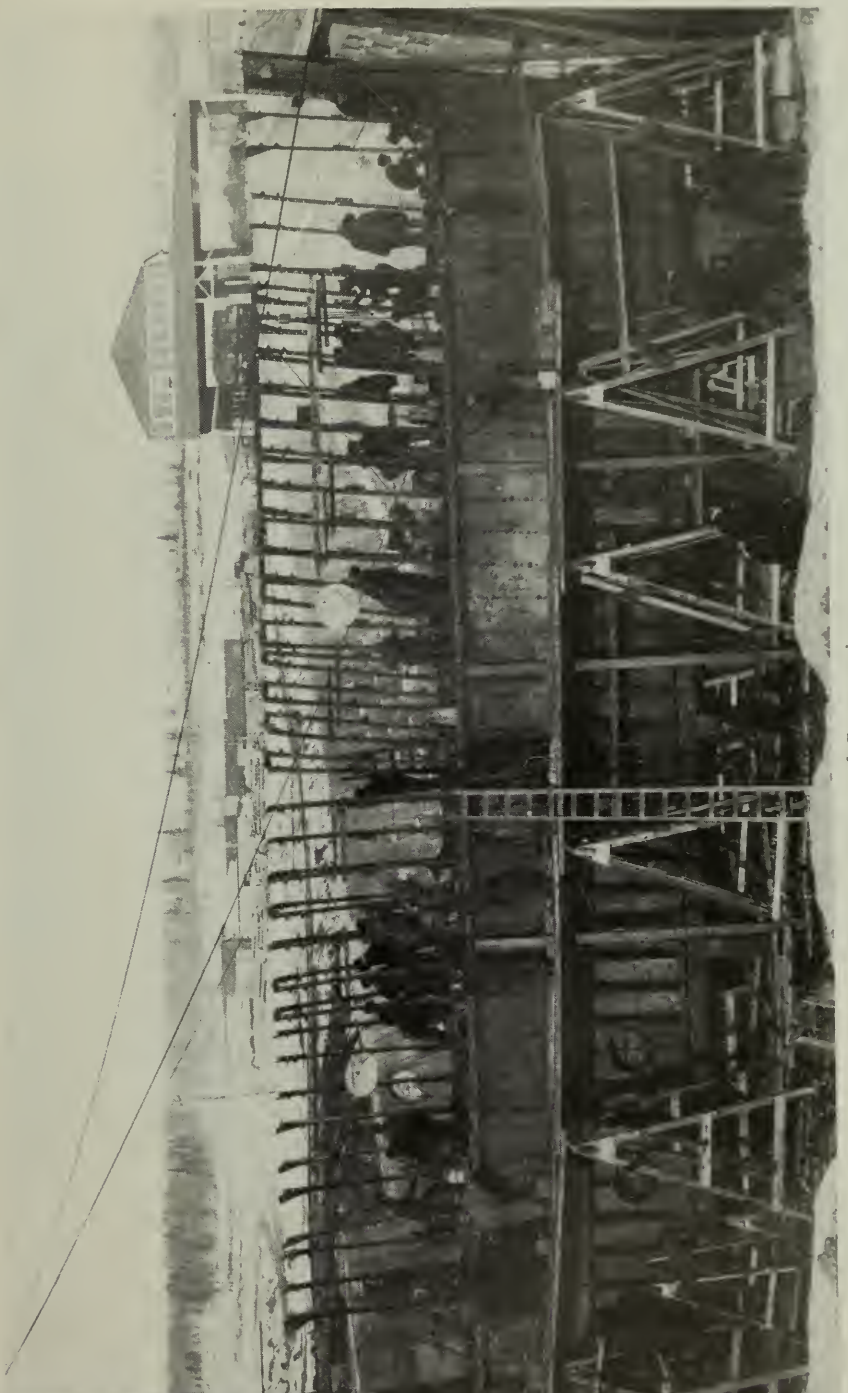
Great Lake shipping on the Canadian side has long been hampered by the lack of dry dock accommodation at the head of Lake Superior. This condition, with the opening of the new dry dock just completed for the Western Dry Dock and Shipbuilding Company, will cease to exist, and an impetus will be given to the building of vessels and to its allied industries. The new dock is capable of holding the largest vessels on the lakes, it being 700 ft. long, and having a clear span at the portal of 77 ft. 6 in., with 21 ft. of water from the sills. It is constructed throughout of concrete and steel and rests upon a rock foundation.

To cut off the water completely during construction a cofferdam 900 ft. long was built in the shape of a horseshoe, surrounding the site on three sides.



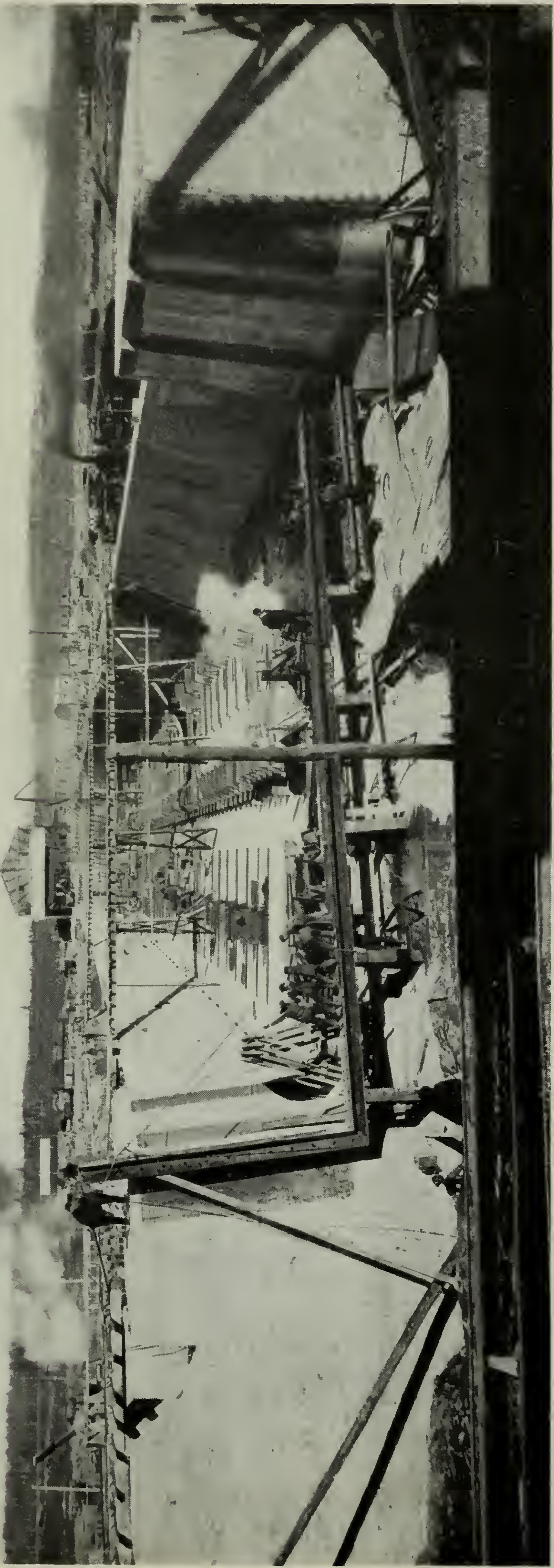
View of Dock during Construction.
Dry Dock at Port Arthur, Ontario.

Two pile drivers were employed, and these, working in opposite directions from the portal end, drove round piles in two parallel rows, 900 ft. long, forming an enclosure around the portal end 300 ft. wide. These piles, spaced 3 ft. centres, formed an outer and inner fence for the 6 in. × 10 in. and 2 in. × 10 in. sheet piling, which was afterwards driven to rock. Waling strips 8 in. × 12 in. were used for the sheet piling, and round pile wales were used for the outside. Steel tie rods were placed across the cofferdam every 3 ft. On top of the round piling and sheet piling a framing was constructed of 8 in. × 12 in. timbers, on which a temporary dinkey track was laid. As fast as the sheet piling was driven earth filling was carried out by means of trains of dump cars operated by dinkey engines. The resulting cofferdam was a very stable structure.



View in Course of Construction.
Dry Dock at Port Arthur, Ontario.

The speed with which the concrete work was done was due to the organisation of the working forces and the efficient arrangement of the plant. Placing concrete was so simplified that from the dredging to the final pouring the work was continuous. Scows



View showing Work in Progress.
Dry Dock at Port Arthur, Ontario.

of 1,000 yards capacity, filled with derricks and clam shells, dredged sand and gravel from Lake Superior, sixty miles from the vicinity of the work, and unloaded it at the portal face upon the cofferdam. Two hoppers placed over a 24-in. conveyor belt, electrically driven, received the materials and alternately fed the belt which led to the mixer tower. Here were two receiving hoppers for sand and gravel, and below were two charging hoppers. These received the proper quantities of sand, gravel, and cement for separate batches of concrete and the whole was run into one of the two mixers below. A new charge was immediately prepared, and this in turn run into the second mixer. In this way, it was possible to have the plant working to its full capacity without intermission. The concrete after being mixed was elevated to cars above by a Ransome bucket hoist. These cars, "V" shaped, of one yard capacity, ran along the top of the dock wall forms, and the concrete was poured directly into the forms. By this system as much as 1,000 yards of concrete were placed by two shifts in one 24-hour day.

The forms for the side walls were made in small sections for convenience in handling. Each section was 5 ft. wide and extended the full height of the wall. Seven of these were placed together and bulkheads were attached at each end. In this way a section of the wall 36 ft. long could be poured, making a huge monolithic block. Alternate 36-ft. lengths were first built, and when the concrete had finally set the intermediate sections were poured. An expansion joint was formed for every 36 ft. of length, and so cracking was obviated.

The dock proper is 85 ft. 4 in. wide at the floor level and 98 ft. 8 in. at the top of the walls. It is 700 ft. long, and a further length of 28 ft. 6 in. within the portal may be utilised. Spaced every 18 ft. in the side walls are three altar steps, designed to hold lateral bracing when a vessel is in the dock.

The floor is solid concrete from 2 to 4 ft. thick, sloping towards a central drain, which terminates in a rudder well at the portal end. From the rudder well a drain protected by an iron grating gives access to the pumping well, situated in the west portal pier. With a view to future extension this drain was duplicated on the opposite side of the pumping well, so that when a second dry dock is built parallel to the present basin one pumping outfit will serve for both.

The portal walls are solid masses of concrete faced with concrete of a 1 : 3 : 5 mixture, which is also used in the side walls. The outside corners are curved and protected from injury by steel plates, firmly attached by means of steel angle anchors embedded in the concrete. The portal jambs and sills are faced with steel. Angles 6 × 6 × $\frac{3}{4}$ in., firmly fastened to the concrete floor by 3 × 3 × $\frac{1}{2}$ in. angles, 4 ft. long, spaced every 2 ft., form a connection for the 16 × $\frac{3}{4}$ in. plate against which a heavy steel gate rests. Strong lateral anchors embedded in the portal piers hold the jambs in position. Great care was exercised in placing this steel framework to obtain a truly vertical and longitudinal alignment.

A feature of interest is the construction and arrangement of the bilge and keel blocks with their attachments. The slides upon which the bilge blocks move, spaced 12 ft. apart on each side of the dock, are made of 3 × 14 in. white oak timbers bolted every 2 ft. Split anchor bolts, $\frac{3}{4}$ × 18 in., fasten them securely to a concrete base, and the nuts are counter-sunk, leaving a smooth upper surface, on which the bilge blocks slide. These are 4 ft. 6 in. in height, of 12 × 12 in. Oregon fir timbers. They are drift bolted together at the ends, and are furnished with slide irons and wooden slide blocks clamping them to the slides.

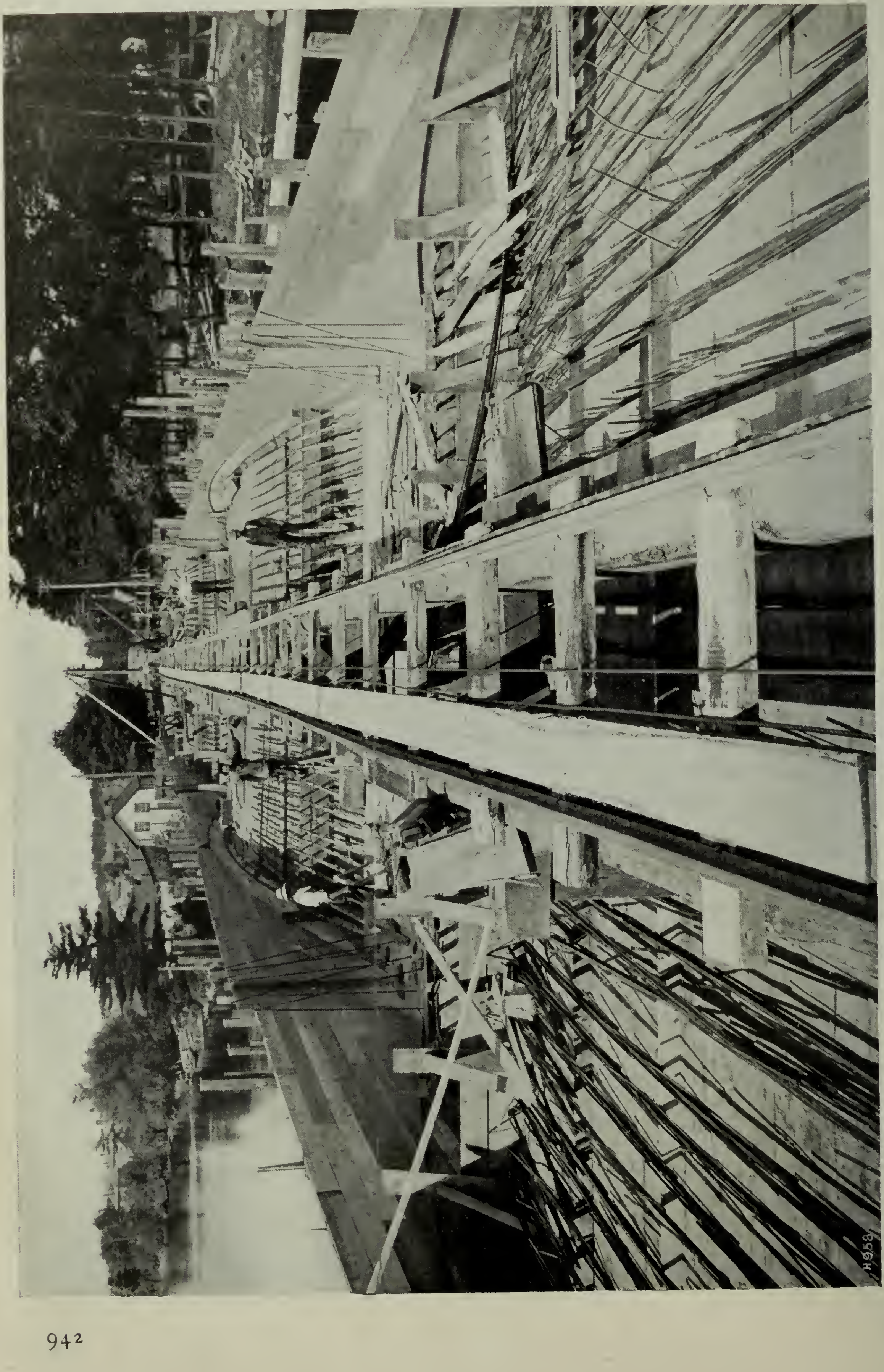
Two hauling chains are attached to each block by means of "U" bolts, and two fair leaders are attached to the dock wall, one at the lower angle and the other near the top. The keel blocks, constructed of 12 × 12 in. white oak timbers, bolted together with 1 × 20 in. lag screws, rest on a 12 × 14 in. white oak timber set in the concrete floor, and fastened thereto with 24-in. expansion bolts. These are spaced 6 ft. apart and extend from the rudder well to within 12 ft. of the shore end of the dock.

Five-ft. concrete sidewalks run the full length at each side, and four reinforced concrete stairways lead from their ends to the top of the dock walls.

The contractors for the work were the Canadian Stewart Company, Limited, and it was carried out under the direction of Wm. R. Sinks, manager, and R. H. Folwell, engineer for that company.

A LARGE REINFORCED CONCRETE BRIDGE AT PETERBOROUGH, ONTARIO.

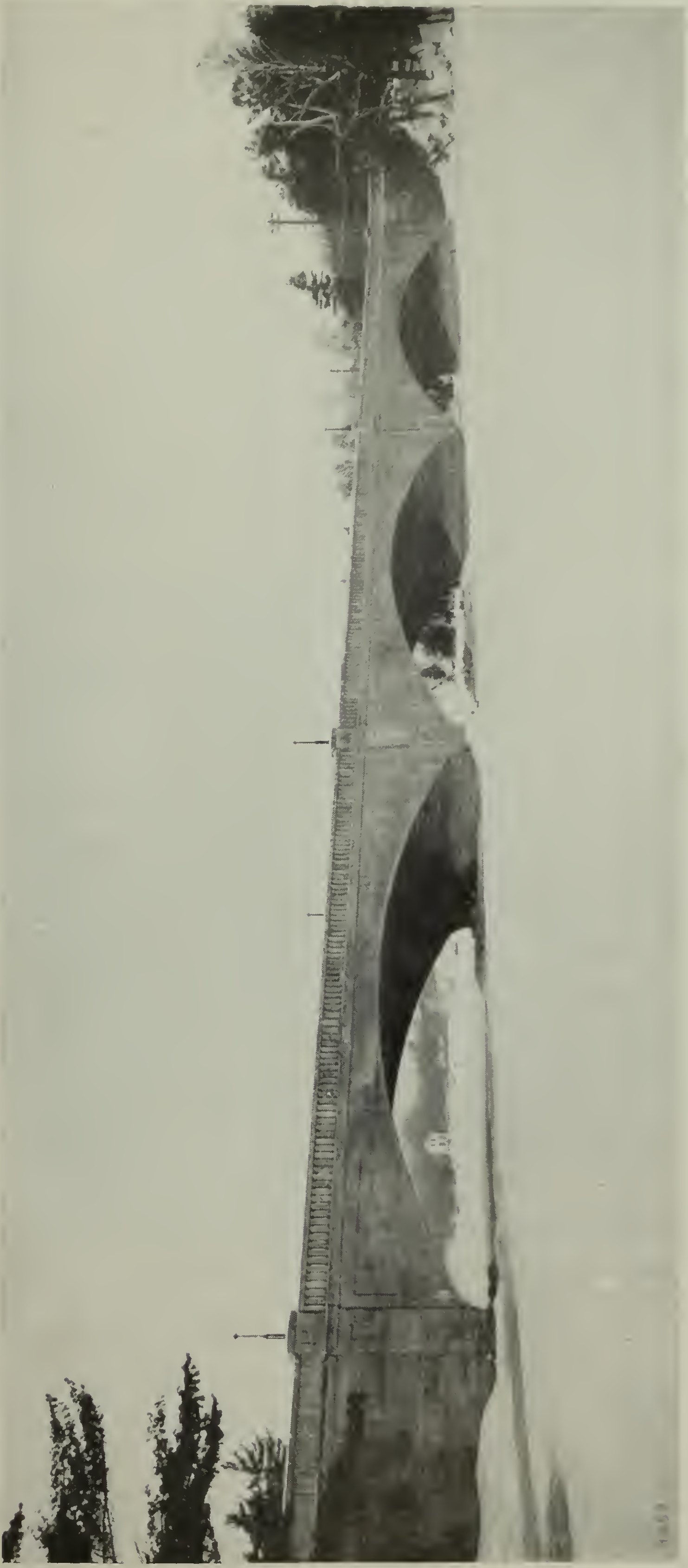
THIS structure, known as the Inverlea Bridge, consists of three arched spans of reinforced concrete, 100 ft. centre to centre, or 94 ft. clear, with abutments reaching well into the river banks on both sides and beyond the shore lines, making a total length of structure of 385 ft.



View in Course of Construction.

Reinforced Concrete Bridge at Peterborough, Ontario.

The arches were designed to sustain a maximum live load represented by a 15-ton road-roller. The clear width between railings is 31 ft., sidewalk 5 ft. wide on south side, a space 10 ft. wide for single track street car line on north side, and 16 ft. roadway between. The centre line of the bridge makes an angle of 72 degrees with the channel of the river. The intrados of arch is a two-centre curve of 3 ft. 9 in., 120 ft. radii, and a rise of 12 ft. The extrados is a segment of a circle of 170 ft. radius. The arches have a radial thickness of 22 in. at crown to 48 in. at the point of lesser radius, 45 ft. from crown.



View of Finished Bridge.

REINFORCED CONCRETE BRIDGE AT PETERBOROUGH, ONTARIO.

The footings of abutments and wing walls are carried up to 3 ft. below normal level of water, and those of channel piers to 5 ft. The width of footings of the wing walls is 5 ft. 3 in., of the abutments 12 ft., and of the piers 9 ft. 8 in.

The piers above footings are battered 1 in 8 to 6 ft. wide at top, with belt course extending 3 in.; bull-nosed ends protected with 5-16-in. plate iron.

The concrete in spandrel walls is composed of one part cement to seven parts gravel and stone. They are 18 in. thick at top, battered inside 1 in 4 and panelled outside 2 in. deep. The concrete in wing walls is of the same composition as spandrels. They are 18 in. thick at top, increasing by 9-in. steps at every 3 ft. vertically.

The handrail is composed of concrete one part cement to six parts gravel and sand. The part over arches is a balustrade of 6 × 8 in. balusters, with 6-in. spaces. That along the wing walls is solid, 8 in. thick. The base of railing is 16 in. wide by 15 in. deep. The cap is 12 by 8 in. The rail is terminated at outer ends of wing walls with posts 18 × 18 in.

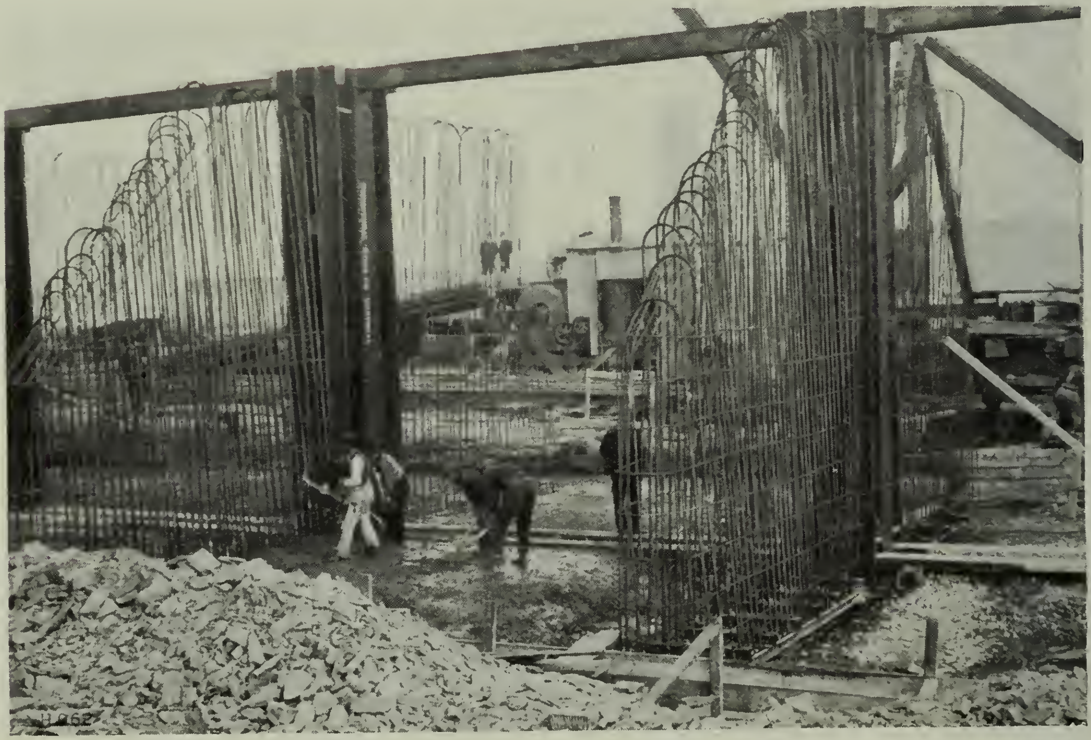
All concrete above water was mixed and run as liquid as practicable to ensure filling. Expansion joints, tongue and groove, were made in spandrel walls and railings over each arch.

The reinforcing adopted throughout the structure consists of the Kahn System, manufactured by the Trussed Concrete Steel Company of Canada, Limited.

The bridge was designed by Mr. T. A. S. Hay, City Engineer, of Peterborough, and our particulars are taken from an article contributed by him to the *Contract Record.*

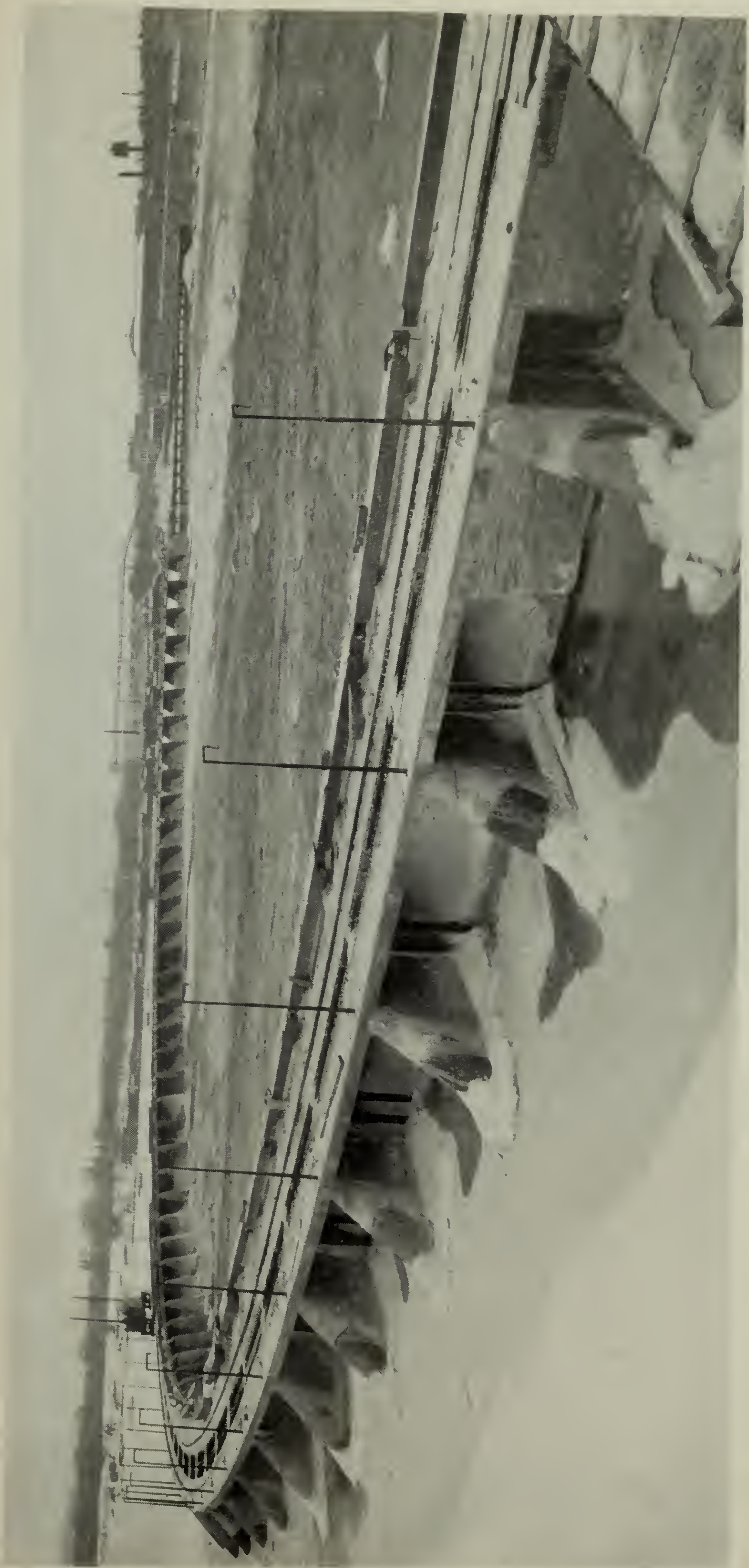
THE CHAUDIERE DAM, OTTAWA, ONTARIO.

THE great Chaudière Dam was built, at a cost of $225,000 (£45,000), by the power owners of the Ontario and Quebec sides of the Ottawa river. It is of steel and concrete construction, and is of the pier and sluice type. There are 49 piers and two abutments, the piers being 22 ft. high and 39 ft. 5 in. long. The following description of the construction appeared in our contemporary, *The Canadian Engineer:*



View showing Reinforcement for Piers.
THE CHAUDIERE DAM, OTTAWA, ONTARIO.

The piers, the most important feature of the whole structure, were 39 ft. 5 in. long at the base and battered to give a 23 ft. $5\frac{1}{2}$ in. bridge floor support at elevation 57·75. They had a clear height from stop-log sill to bridge floor of 22·00 ft. Their cross sections at base were modified ellipses, as the ellipse, according to tests in Europe, affords the least obstruction to flowing water. In order that any debris



View of a Portion of the Dam in Course of Construction.
The Chaudière Dam, Ottawa, Ontario.

which might pass the noses of two piers might not wedge between their downstream ends, owing to the convergence by their radial setting, the piers were made 4 ft. wide at the nose or upstream end, tapered to 2 ft. at the tail or downstream end. This gives, between piers, 22 ft. of a clear sluice-way at the upstream entrance and 22 ft. 5¾ in. at the downstream exit.

In designing the piers, water at elevation 52·00 and causing a pressure of 100 tons acting at elevation 42·00 was used in conjunction with an ice pressure of 200 tons acting at elevation 50·00. To counterbalance the effect of this turning moment an anchorage of rock bolts capable of developing a stress of 200 tons was placed in the front section.

These piers were founded on the solid Trenton limestone bed-rock. Where fissures or cracks occurred a cut-off trench of 1 : 3 : 6 concrete was put in. This same mixture (1 : 3 : 6) was used in the foundations, while above elevation 37·00 in the piers and bridge floor 1 : 2 : 4 concrete was the order; 1¾-in. round anchors (21 to the pier) were securely grouted into the solid rock. These were set in pairs, having their upper ends secured by nuts and washers over two 5-in. channels at 6·50 lb., which rested on four 4-in. channels at 5·25 lb., two on each side of the pier. These 4-in. channels were placed with lower flanges at elevation 35·50 and ran the length of the pier. A space between each pair of channels allowed the vertical reinforcement to pass from the under side where the upset ends of the rods were secured by nuts and washers to the channels, through and up with centres 6 in. from outside of pier to beneath the nosing plate and bridge floor, where the rods were bent in a semicircle, and came down to be secured underneath the pair of channels on the opposite side of the pier. In the upstream portion, or that above the stop-log posts, the vertical rods were 1¼-in. round at 6-in. centres, while below the posts, or downstream, they were ¾-in. round at 9-in. centres. Running outside of these upright rods were ⅜-in. horizontal round rods spaced at 16-in. centres and wired to the vertical members. There were also nine ¾-in. rods in the rounded ends of the nose, which were bent up parallel to the latter; a like number of ⅝-in. rods were used in the downstream ends. These rods were set in the foundation matrix and not connected with the system of anchors. Above elevation 46·00 ⅞-in. rods, 21 ft. long, in sets of three were put in horizontally to bind the upstream and downstream portions together.

To protect the concrete on the face of the upstream batter from the pounding of ice or logs, ½-in. rounded nose plates 11 ft. 7½ in. long were securely anchored to the concrete backing.

With the 1 : 2 : 4 concrete surrounding the steel reinforcement, the pier became a permanent structure securely bound to the solid bed-rock on which it rested.

An additional rigidity was imparted by the reinforced concrete bridge floor, which united the tops of the piers. This floor was 23 ft. 5½ in. wide and 15 in. deep. It was reinforced by ¾-in. straight round rods at 6-in. centres on the bottom and by ½-in. rods on top at 6-in. centres. The web reinforcement consisted of ¼-in. stirrups wired at right angles to the main reinforcement in the top and bottom tension members. The floor was divided into two parts by the stop-log opening, which was 4 ft. 5 in. wide. This opening was divided in the centre into two parts by two 12-in. channels at 20·5 lb., separated by bolts and piping. This left 19 in. for each stop-log way. The two sides consisted of a 3 × 3 × 7-16 angle on a 12-in. channel at 20·5 lb. anchored to the floor slabs. The angles were so placed as to form checks for a wooden covering of the opening. The upstream portion of floor carried the winch rail, poles for winch wire, etc., while the downstream carried the other winch rail and two skids (at 16 ft. centres), which supported the stop-logs when not in use. The winch rails consisted of a ⅞-in. bar on upstream rail and ¾-in. on downstream rail, curved to proper radius, and riveted to a 7⅞ × 7⅞-in. H beam. The top flooring consisted of 1 in. of 1 : 2 cement mortar. Expansion joints of tar paper, lead, and asphalt were laid every fifth pier.

The concrete in the central section of piers was poured in zero weather, and special precautions were taken to ensure a good quality of work. The sand used in the concrete was heated by blowing steam through it, and the mixer was fed by a steam jet, which thoroughly heated the mix. This was poured into the pier forms, which had previously been saturated with live steam for 24 hours. The steam was kept on under the tarpaulins for another 12 hours, and then sawdust and manure were packed on the top of the moulds. The forms were left on till the following summer.

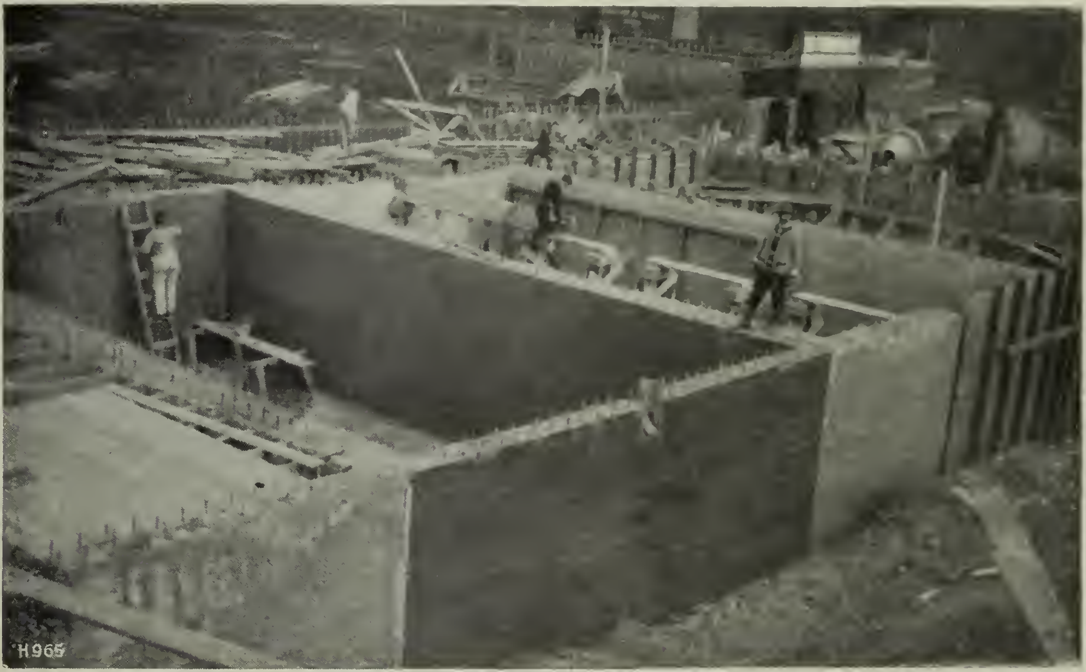
The engineers for this work were Mr. Wm. Kennedy, Junr., of Montreal, who prepared the designs and plans, and Mr. J. B. McRae, of Ottawa.

REINFORCED CONCRETE TANKS FOR STORING GASOLINE, TORONTO.

Four reinforced concrete tanks for the storage of gasoline have recently been completed for the Queen City Oil Company at West Toronto.

On account of certain city regulations these tanks were placed below ground and completely backfilled on top. Owing to confined space, the tanks were built rectangular in form (each tank 21 ft. 6 in. × 38 ft. long × 9 ft. 6 in. high), having total exterior dimensions of 94 ft. × 40 ft. × 6 ft. The tanks are to be filled by gravity from tank cars and used for the distribution of gasoline in West Toronto.

Work was started by excavating to just above the water level in the soil. This excavation was taken out by scraper teams, the final trimming being done by benching out. A concrete mat was deposited all over the bottom of the excavation, and on this were built four tanks side by side, but independent one of the other. A tile drain surrounded by broken stone was placed around at the bottom and on the outside of the walls. This drained into two sumps, one on each side at the centre of the four tanks. Square reinforcing steel was used throughout, and the concrete was of a rich, dense mixture. The walls and floor were poured continuously, so as to do away with any bonding of old and new concrete, the gang working as late into the night as was necessary to complete each tank.



View of tanks in course of construction.
Reinforced Concrete Tanks for Storing Gasoline, Toronto.

To economise time the forms of two tanks were set up at one time, and after these had been poured and the concrete sufficiently set the forms were stripped off and set up again for the remaining two. After the walls had hardened sufficiently the roof and its supporting columns were placed and the slab poured. Two manholes were left in the roof of each of the tanks. These are to be used for the intake and discharge pipes, and also for the cleaning out of the tanks. At the completion of the work a water test under a maximum head was made on each tank. These tests showed the tanks to be perfectly tight.

The above tanks were designed and built for the Queen City Oil Company by the Foundation Company, Limited, Bank of Ottawa Building, Montreal.

HOW TO FIND THE MAXIMUM DEFLECTION FOR A UNIFORMLY LOADED BEAM FIXED AT ONE END AND SUPPORTED AT THE OTHER.

By H. KRUSE, M.Inst.C.E.Copenhagen.

In our last issue we published an article entitled "A Problem in Deflection of Beams," in which Mr. Ewart S. Andrews, B.Sc., gave a method of finding "the maximum deflection for a uniformly-loaded beam fixed at one end and supported at the other." Mr. H. Kruse now asks us to publish his method of solving this problem, which we give below.—ED.

In the following the writer endeavours to solve this problem without the use of infinitesimal calculus and by a method that may be applied generally for any case of loading and support. The method is based on the following well-known maxims :—

1. The deflection of a beam is found as the bending moment in an imaginary beam of same span, simply supported at the ends and loaded with $\frac{M}{EI}$, M being the bending moment diagram for the original beam.

2. The bending moment in a simply supported beam is maximum at the section where the shearing force is O.

Considering the beam in question, the bending moment diagram, represented by the shaded area in *Fig.* 1 is equal to the difference between the two areas $A\ B\ F\ D\ C$ and $A\ B\ G\ D\ J$. We can now consider the imaginary beam loaded first with the one area (see *Fig.* 2), and then with the other area (see *Fig.* 3), acting in opposite direction to the first, and then find the shearing forces s and S in each case, in a section at distance x from B.

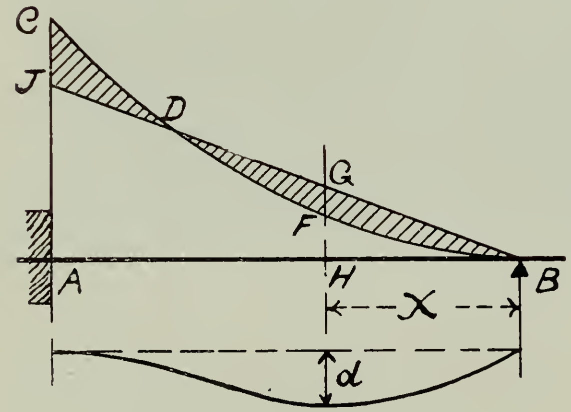


FIG. 1.

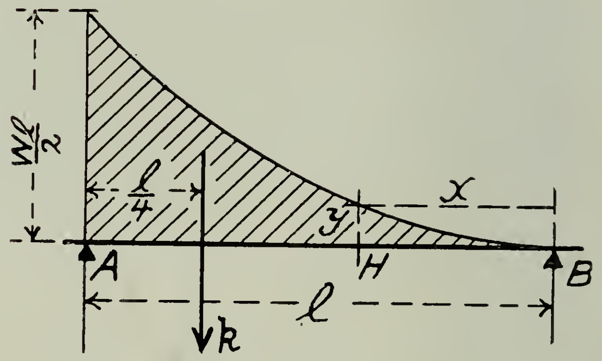


FIG. 2.

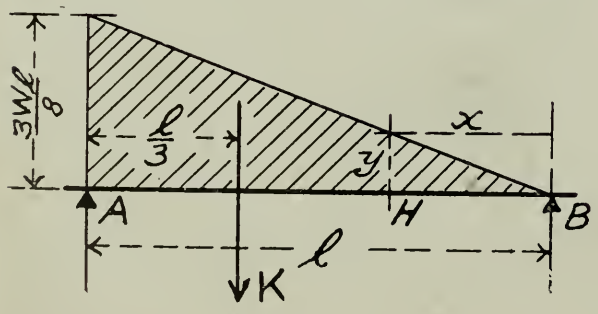


FIG. 3.

As the maximum bending moment in the imaginary beam represents the deflection, this will be maximum where the difference between S and s is o, or for $S - s = o$ (according to maximum 2).

1ST CASE (see *Fig.* 2).

The total load on the beam is $k=\frac{Wl^2}{6}$, the reaction at B is $\frac{Wl^2}{24}$, and consequently the shearing force at H is $s=\frac{Wl^2}{24}-\frac{xy}{3}$ (3)

The equation for the parabola is: $y=\frac{Wx^2}{2l}$, and substituting this value for y in (3) we get: $s=\frac{Wl^2}{24}-\frac{Wx^3}{6l}$

2ND CASE (see *Fig.* 3).

The total load on the beam is $K=\frac{3Wl^2}{16}$, the reaction at B is $\frac{Wl^2}{16}$, and consequently the shearing force at H is $S=\frac{Wl^2}{16}-\frac{xy}{2}$ (4)

We see from *Fig.* 3: $y=\frac{3Wx}{8}$, and substituting this value for y in (4) we get: $S=\frac{Wl^2}{16}-\frac{3Wx^2}{16}$. By taking $S-s=o$ we get $\frac{Wl^2}{16}-\frac{3Wx^2}{16}-\frac{Wl^2}{24}+\frac{Wx^3}{6l}=o$, or

$$8x^3-9lx^2+l^3=o, \qquad (5)$$

and solving this equation for x and leaving out inadmissible values, $x=0{\cdot}4215l$.

Having found the location of the maximum deflection, we now proceed in a similar manner to find the size of it by taking the bending moments in each case of the imaginary beam.

1ST CASE (see *Fig.* 2).

Bending moment at H is $m=\frac{Wl^2x}{24}-\frac{xy}{3}\cdot\frac{x}{4}=\frac{Wl^2x}{24}-\frac{yx^2}{12}$, or as $y=\frac{Wx^2}{2l}$

$$m=\frac{Wl^2x}{24}-\frac{Wx^4}{24l}=\frac{Wx}{24l}(l^3-x^3)$$

2ND CASE (see *Fig.* 3).

Bending moment at H is $M=\frac{Wl^2x}{16}-\frac{xy}{2}\cdot\frac{x}{3}=\frac{Wl^2x}{16}-\frac{yx^2}{6}$, or as $y=\frac{3Wx}{8}$

$$M=\frac{Wl^2x}{16}-\frac{Wx^3}{16}=\frac{Wx}{16}(l^2-x^2)$$

The total bending moment on the imaginary beam at H is then:

$$D=M-m=\frac{Wx}{16}(l^2-x^2)-\frac{Wx}{24l}(l^3-x^3)=\frac{Wx}{48l}(2x^3-3lx^2+l^3) \qquad (6)$$

The deflection of a point of the beam at distance x from B is then: $d=\frac{D}{EI}$, and putting $x={\cdot}4215l$ we get

$$d=\frac{{\cdot}4215W}{48EI}(2\times{\cdot}07488-3\times{\cdot}1777+1)l^3=\frac{{\cdot}4215Wl^3}{48}\times{\cdot}6167=\frac{Wl^3}{184{\cdot}5EI}$$

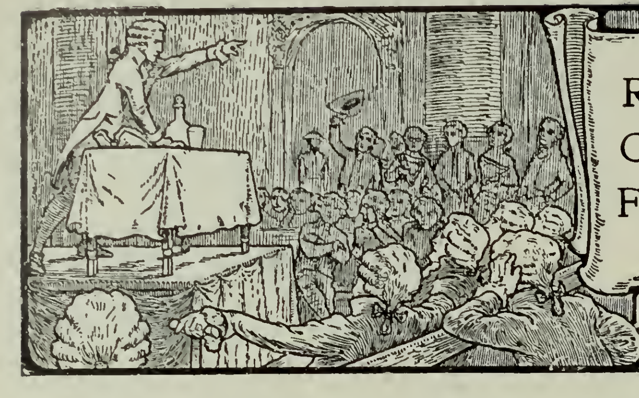
equal to maximum deflection.

The point where the maximum deflection occurs may also be found from equation 6 by means of calculus in the following way:

By differentiation of (6) and leaving out the constants we get

$$\frac{d_D}{dx}=x(6x^2-6lx)+2x^3-3lx^2+l^3=8x^3-9lx^2+l^3,$$

and as D is maximum for $\frac{d_D}{dx}=o$ the point of maximum deflection is decided by $8x^3-9lx^2+l^3=o$, which equation is seen to be identical with (5).



RECENT VIEWS ON CONCRETE AND REINFORCED CONCRETE.

SOME PAPERS & DISCUSSIONS.

It is our intention to publish the Papers and Discussions presented before Technical Societies on matters relating to Concrete and Reinforced Concrete in a concise form, and in such a manner as to be easily available for reference purposes.

The method we are adopting, of dividing the subjects into sections, is, we believe, a new departure.—ED.

THE INSTITUTE OF CHEMISTRY.

CEMENT.

By Mr. BERTRAM BLOUNT, F.I.C.

The Council of the Institute of Chemistry have inaugurated a series of lectures, the first of which was delivered by Mr. Bertram Blount, F.I.C., at King's College on Thursday, October 26th. A second lecture on Cement was given by Mr. Blount on December 1st.

In the unavoidable absence of the President, Dr. Beilby, the chair was taken by Professor J. Millar Thomson, LL.D., F.R.S., who opened the proceedings with a reference to the scheme of lectures, which, he said, was an extension of the work of the Institute on lines mainly directed to benefit advanced students of chemistry. Its aim would be to indicate the scope and object of the work actually carried out in various branches of professional chemical practice, as distinct from academic training; while occasionally the lectures would deal with matters of forensic and ethical interest. Except for one or two lectures delivered in its early history, the Institute had not assumed in any way the functions of a teaching body, though the Charter provided for such functions. The relations between teachers of chemistry and other professional chemists had been made closer in recent years, mainly owing to the high standard of scientific ability attained by so many who devoted themselves to the chemistry of everyday life and of industrial processes. The Council thought it would be a good thing if younger chemists were brought into touch with the actual practitioners, as men whose experience had revealed the directions for future developments.

Professor Thomson then welcomed the Institute to King's College, and called upon Mr. Blount to deliver his lecture, the first of two, on "Cement."

Abstract of Mr. Blount's Paper.—The lecturer limited his discourse to the consideration of calcareous cements as being of predominant importance, and more particularly to the Portland cement industry, the size of which may be judged by the fact that the world's production is estimated at 25,000,000 tons per annum, valued roughtly at £35,000,000. The industry is essentially a chemical one, and, in the interests of both manufacturer and consumer, is, and should be, controlled by the chemist.

The earliest form of calcareous cement is probably calcium sulphate sufficiently dehydrated to form plaster of Paris. Its disadvantages lie in its lack of plasticity and its liability to attack by water. On the other hand, calcareous cements, properly so-called, while being plastic, are capable of hardening and are resistant to water. The common fallacy, that the setting of lime mortar is due to the action of lime on the sand with which it is mixed, was once more exploded by the lecturer. It has long been known that some siliceous materials have an advantage over others as aggregates for mortar. These are known generally as "pozzolanas," and their usefulness depends on the fact that they contain hydrated silica or attackable silicates which interact with lime and form compounds more or less resistant to the action of water. Similarly, it has been known that some limestones are better than others in providing strong and resistant lime for mortar. There seems to be no record that limestones were deliberately and intelligently chosen for the hydraulic quality of the lime which they furnished until the time of Smeaton, who, in considering with what material he should build the Eddystone Lighthouse, ascertained that Aberthaw limestone was undoubtedly hydraulic, and desiring to know why, applied to Mr. Cookworthy, a chemist of the period, whose office as consultant was creditably fulfilled. It was found that those limestones which were most hydraulic contained the largest proportion of argillaceous material. But not content with this, he reasoned that this quality might be improved by the addition of what was then known to be capable of conferring hydraulic properties on ordinary lime, and, accordingly, used trass, a pozzolanic material.

From the subject of hydraulic limes the lecturer went on to discuss the manufacture of so-called "Roman Cement," a crude form of Portland cement made by burning lumps of clayey limestone. The foundations were thus being laid of one of the largest chemical industries in the world. Starting with the notion of imitating Roman cement, the progenitors of the Portland cement industry arrived at the idea that when chalk and clay were mixed and burned an hydraulic material was produced which, when ground, would set and form a strong, sound cement. The function of the chemist who concerns himself with this industry was dealt with at some length. When a new works is to be started, there has to be considered the nature and available quantity of the raw materials, the accessibility of a supply of fuel, the suitability of the proposed site, the choice of process, and the appropriate plant, and such matters of transport, supply of labour, and probable markets, which go far to determine the commercial success of any undertaking. The function of the chemist continues after the works are started, and on him depends the smooth control of the quality of the cement produced.

THE BOSTON SOCIETY OF CIVIL ENGINEERS.

A NEW THEORY FOR THE DESIGN OF REINFORCED CONCRETE RESERVOIRS.

By Mr. HIRAM B. ANDREWS.

Below we give an abstract of a paper on "A New Theory for the design of Reinforced Concrete Reservoirs," which was read by Mr. H. B. Andrews before the Boston Society of Civil Engineers some time ago, and which was published in the "Journal of the Association of Engineering Societies" of America.

THE theory which the writer is exploiting is derived by a process of evolution in the construction of several reservoirs in the past five years in which the writer has been directly interested either from an engineering or contracting standpoint or both.

As there is a tendency for the diameter of a reservoir to increase after it is filled with water, due to the elasticity of the steel in tension, and as the base of the reservoir is practically rigid, due to its intimate contact with the foundation upon which it rests, it has been deemed necessary to install some reinforcing material extending from the base up into the walls to take care of the bending moment and shear at the base. The writer does not know, nor has he been able to find any exact method of obtaining the amount of steel required here, but he thinks that in most cases heretofore it has been underestimated.

As the several operations of building up forms, placing steel and concrete preclude making the concrete work continuous, it is advisable to make as short intervals as possible between successive layers of concrete, and where these joints occur to bond together the successive layers in the best possible manner. These instructions as outlined were followed out in the construction of the reservoirs at Waltham, Manchester and Lisbon Falls, designed by the author, except that the two latter reservoirs were made with a 1 : 1½ : 3 mixture of concrete plus 5 per cent. hydrated lime. For the Manchester reservoir the thickness of the wall at the base is 20 in., and at the top 12 in. The steel is designed for a unit working stress of 12,000 lb. per sq. in. when the reservoir is full of water. At the base are installed rods which are embedded in the floor and turned up into the walls. These rods are 1 in. in diameter and are laid 12 in. on centres and extend into the wall about 4 ft. 6 in. The floor was finished with 1 in. granolithic, and the walls were plastered with two coats, making about 1 in. in thickness of 1 : 1 cement mortar. But after the filling of the reservoir various features were observed which showed that some improvement might be made in the design of future work.

We emphasise this word, "design," as the workmanship on this reservoir was done with the utmost care and the material was of the best quality, and we do not see where it could be materially improved in this respect.

There developed at several of the horizontal joints—and especially at the three lower joints—between day's works, some seepage of water, which in three places increased to positive leaks. The seepage, however, at the upper joints gradually stopped, presumably due to the filling of the pores by hydrated lime. We at first saw no reason why any leakage should develop. We had supposed that the concrete was rich enough, that the inside coating of 1 : 1 plaster, put on in such a manner as to make a double lap over the joints, and the care taken in grooving and grouting the joints between day's works, were sufficient to make the reservoir absolutely tight, and when we found that a little leakage did occur after taking all these precautions, we naturally began an investigation to determine the reason or reasons therefor, and to obtain for future work some protection against it. Upon examination of the reservoir after it was emptied, we found that there were horizontal cracks at the joints mentioned, about 30 ft. long and extending through the wall, also that there were vertical cracks in the plastering extending upward for 20 ft. or so, and futhermore, that there were checks in the plastering from which the water oozed back into the reservoir after it was emptied.

From these observations we made the following deductions : That there was not enough vertical steel properly distributed to fully distribute the bending moment and shearing stress between the rigid base and the walls, and that the lack of this probably was the cause of the horizontal cracks; second, that the ultimate strength of the concrete was probably exceeded when the reservoir was filled with water, thus producing the vertical cracks, and that these vertical cracks allowed the water to permeate into the walls and through them to the lines of least resistance, which would be the horizontal joints; third, that the addition of a rich plaster coat with a more or less permeable concrete back of it was useless, as the usual crazing and the vertical cracking which would occur due to the tension would also allow the percolation of water through it.

This second deduction is the basis of this paper. From tests which have been made on concrete beams it has been found that microscopic cracks have developed in the concrete on the tension side when the steel reinforcement was stressed to 4,000 or 5,000 lb. per sq. in., or perhaps less; that these cracks gradually widened until they were finally visible. It is presumable that these cracks began when the ultimate strength of the concrete in tension was reached, and at a time that the unit stress in the steel was approximately ten times that in the concrete. These microscopic cracks were made visible by the application of water, and water-lines following them could be seen. If these cracks developed in beams when the stress in the steel was only 5,000 lb. or thereabouts, sufficient to admit water, why should they not develop in reservoir walls when the steel was stressed to the same point? And furthermore, if the walls were made so thin that they took little of the tensile stress, it being all thrown in the steel at 12,000 or 16,000 lb. per sq. in. or at any intermediate working value between these, why should not vertical cracks show in the walls and permit water to seep into the walls?

One of the first requisitions in a concrete reservoir is to make it water-tight. The writer did not see how he could be sure that it would be water-tight if he so designed it; that the cracks in the concrete were predetermined. The only remedy seemed to be to make the walls so thick, and of such a composition, that their tensile strength would never be exceeded.

Having this in mind when we came to the design of the reservoir for Rockland, Mass., and after consultation with Mr. J. R. Worcester and Mr. Sanford E. Thompson to obtain their ideas and approval of an innovation in the construction, we decided to use an especially rich mixture of concrete, a thickness of wall which would insure that the ultimate tensile strength of the concrete would not be reached when the reservoir was filled, to use an increased amount of vertical reinforcement especially between the base and the walls, and to install a steel dam at each horizontal joint between each day's work to prevent any direct seepage of water through the joint, provided it entered it. The hydrated lime was omitted, as we considered the proposed density of the concrete did not require it for unpermeability, and also that where it had been used previously it had caused an unsightly efflorescence on the wall wherever there had been seepage. The plastering was omitted as we considered that any rigid coating upon this mixture of concrete was unnecessary; but instead, we applied three coats of soap and alum solution, to fill pinholes due to air bubbles, etc.

The thickness of wall at the base was determined as follows. We assumed that a 1 : 1 : 2 concrete in tension was good for approximately 400 lb. per sq. in., that the working stress in the steel, if by any chance the full tension was thrown upon it, would be 16,000 lb. per sq. in., and that the ratio of moduli of elasticity between steel and concrete was 10, so that if the concrete was stressed to 300 lb. per sq. in. the steel would be stressed to 3,000. The tension at the base of a standpipe 46 ft. in diameter and 104 ft. in height when filled with water would be $62\frac{1}{2}$ by 104 by 23, equal to 149,500 lb. per ft. in height. At 16,000 lb. per sq. in. this would require 9·35 sq. in. of steel per foot in height at the base, which was the section used. We made the thickness of wall 36 in. at the base, the sectional area of concrete being (36 by 12) − 9·35, equal to 422·65 sq. in.

Let X equal unit stress in concrete, and $10X$ the unit stress in steel, then $422{\cdot}65X + 9{\cdot}35\,(10X) = 149{,}500$ lb.; solving, X equals 290 lb., which was considerably lower than the ultimate strength of 400 lb. which we assumed. As we could find no tests of concrete in tension, we decided to have some made of large-sized briquettes at the Watertown Arsenal. We thereupon ordered our superintendent of construction on the Rockland job to make up some briquettes of special design, having a minimum cross section 4 in. square. These briquettes were made of the same material and in the same manner as the concrete was made for our regular work, the 1 : 1 : 2 concrete being taken from the mixture while the regular work was going on.

We also made twelve 6-in. cubes for testing the compressive strength of the same concretes. The test pieces were made between August 1st and September 8th, and the tests were made sixty days thereafter, between October 20th and November 7th. The average tensile strength of the 1 : 2 : 4 concrete was 113 lb. per sq. in., of the 1 : $1\frac{1}{2}$: 3, 202 lb. per sq. in., and of the 1 : 1 : 2, 281 lb. per sq. in., there being no great variation from this average in any one of the tests. The average compressive strength of the cubes were as follows: 1 : 2 : 4, 2,280 lb. per sq. in.; 1 : $1\frac{1}{2}$: 3, 3,657; 1 : 1 : 2, 4,845. Upon examination of the fractured tension pieces it was evident that the increasing ratio of tensile strength when the richness of mixture was increased was due to the larger amount of mortar in cross section in the 1 : 1 : 2 concrete. As this concrete showed very few stones at the fractured section, while the 1 : 2 : 4 concrete showed a large number, it was plain that the adhesiveness of the mortar to the stones was not equal to the cohesiveness of the mortar.

In regard to the tensile specimens the engineer in charge of the test remarked that "No change in the specimens was observed until rupture occurred. This took place quietly on a plane approximately perpendicular to the axis of the specimens and followed the surface of the gravel in nearly all cases."

From the results obtained we checked our previous assumptions. The average tensile strength of 1 : 1 : 2 specimens was 281 lb. per sq. in. We assumed that in large-sized sections this possibly would be increased 25 per cent., and that if these sections were reinforced by steel, that a further increase in strength of at least 10 per cent. might be expected.

Our first assumption was made by reason of the fact that large-sized specimens in compression usually showed about this percentage of increase over small ones, and our later assumption was based on the following theory.

If an unreinforced section is subjected to tension, when its ultimate strength is approached a crack will develop at the line of least resistance, and the fracture will always occur at this point. If the section is reinforced, the ultimate fracture will not necessarily be at the point where the first crack developed, as the strain would be distributed nearly equally over the entire section by the reinforcing steel, and the fracture would take place at a plane in which was located the resultant of a number of weaker areas of concrete.

We, however, assumed our original figure of 281 lb. increased by first 25 per cent. and then 10 per cent., making a tensile strength of 380 lb. per sq. in., which was probably nearly its actual value in the wall. It has been previously shown that the maximum tensile stress in the concrete would be 274 lb. per sq. in., and the corresponding tensile strength in the steel 2,740 lb., so that there would be a margin of about 40 per cent. left for a factor of safety in the concrete without approaching the limitation on the steel. If, however, our assumptions had been wrong and no tensile stress whatever was taken by the concrete, which would be unreasonable, then we still had steel enough to take all the stress at 10,000 lb. per sq. in. or its ordinary working value.

Applying this same line of reasoning to the Manchester reservoir, it is found that the tension at the base if divided proportionately between the steel and the concrete would be approximately 3,500 and 350 lb. per sq. in. respectively. We have assumed that the ultimate tensile strength of the 1 : $1\frac{1}{2}$: 3 concrete would be 202 + 25 per cent. + 10 per cent., equal to 278 lb. per sq. in., so that it is evident that the tensile strength of the concrete of the reservoir wall is exceeded, and that the vertical cracks developed might be expected.

We further find that at a point 25 ft. up the tensile strength of the concrete plus the tensile stress in the steel just equals the stress due to water pressure at this point, and it was at about this place that the vertical cracks in the plastering disappeared.

There was never any trouble with the Lisbon Falls reservoir. A few damp spots appeared at first on the surface, but these soon disappeared. This reservoir is 62 ft. high and 50 ft. diameter, and the walls are 20 in. thick at the base; 1 : $1\frac{1}{2}$: 3 concrete was used, and a 12,000 lb. per sq. in. working stress on the steel was assumed. The assumptions previously made would show a stress in the concrete of 235 lb. per sq. in. and 2,350 lb. per sq. in. in the steel. This stress in the concrete being less than its ultimate strength, we did not expect to find any vertical cracks with a resultant leakage.

It is hard to say just what factor of safety against bursting there is in a concrete reservoir. We are, however, working on the side of safety in making the walls thick instead of thin.

In view of the experience the writer has had, and from all the outside information he has gained, he would certainly recommend a careful consideration of the subject before using very thin walls on concrete reservoirs of considerable height.

NEW WORKS IN CONCRETE

AT HOME AND ABROAD.

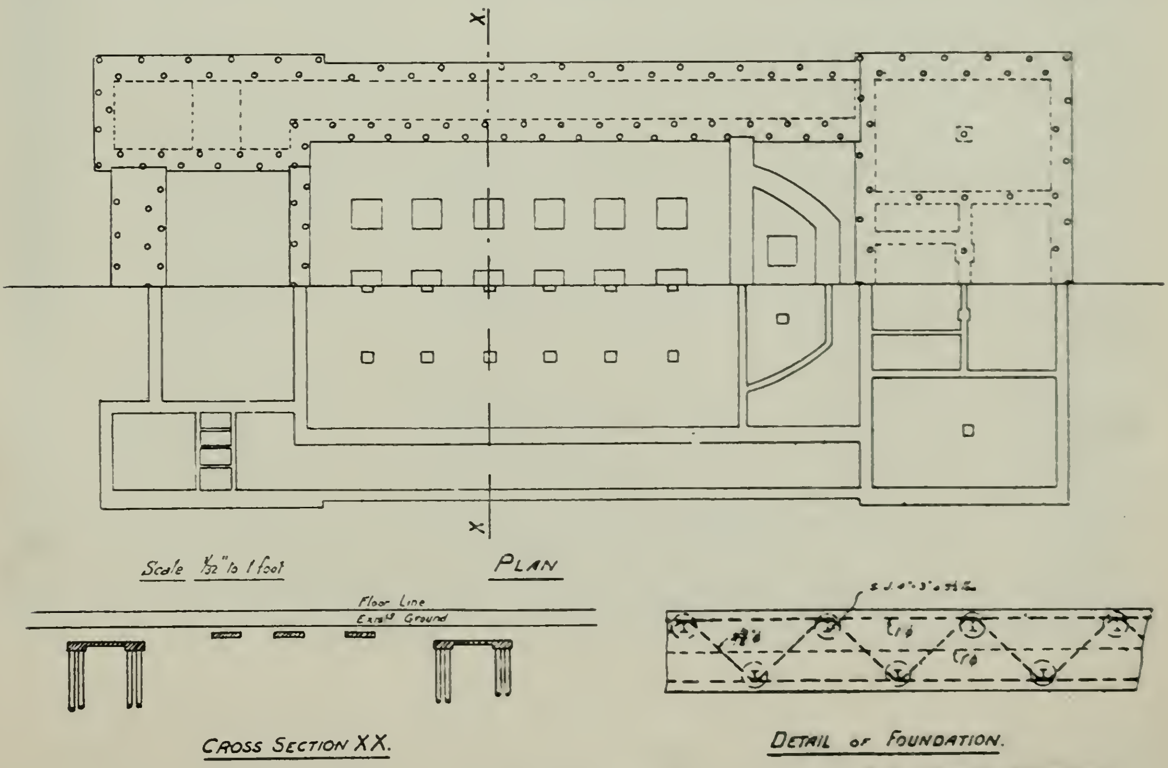
Under this heading reliable information will be presented of new works in course of construction or completed, and the examples selected will be from all parts of the world. It is not the intention to describe these works in detail, but rather to indicate their existence and illustrate their primary features, at the most explaining the idea which served as a basis for the design.—ED.

FOUNDATIONS FOR PERTH CITY HALL.

BORINGS having shown the formation of site for the Perth City Hall to be filled-in ground, overlaying a layer of black alluvial mud, beneath which was ballast (the original bed of the Tay), it was at first proposed to construct a raft foundation framed of steel girders encased in a slab of concrete. The advantages of cast-in-place concrete piles were, however, brought before the architect, who decided to consider a proposal based on this method of construction as an alternative to the raft. Tenders were obtained for both methods, and the piled scheme proved slightly the cheaper, but its superiority in all other respects probably led to its adoption quite apart from the consideration of price.

Two hundred and thirty piles of lengths varying from 14 ft. to 24 ft. were driven, each pile being 16 in. diameter, and reinforced with a 1-in. diameter steel bar placed in centre. The driving of the piles showed the soil to be exceptionally soft mud in places, while at other points fairly stiff ground occurred all the way down to the ballast, into which the piles penetrated about 3 ft. on an average.

A raft foundation on such ground would have been a risky method of construction, owing to the want of uniformity in the resistance offered by the soil. Some difficulty was anticipated in connection with the rather dilapidated property surrounding the site (to be cleared away later by the formation of two new streets), but although the



J. & W. Stewart Contractors

Plan and Details.
FOUNDATIONS FOR PERTH CITY HALL.

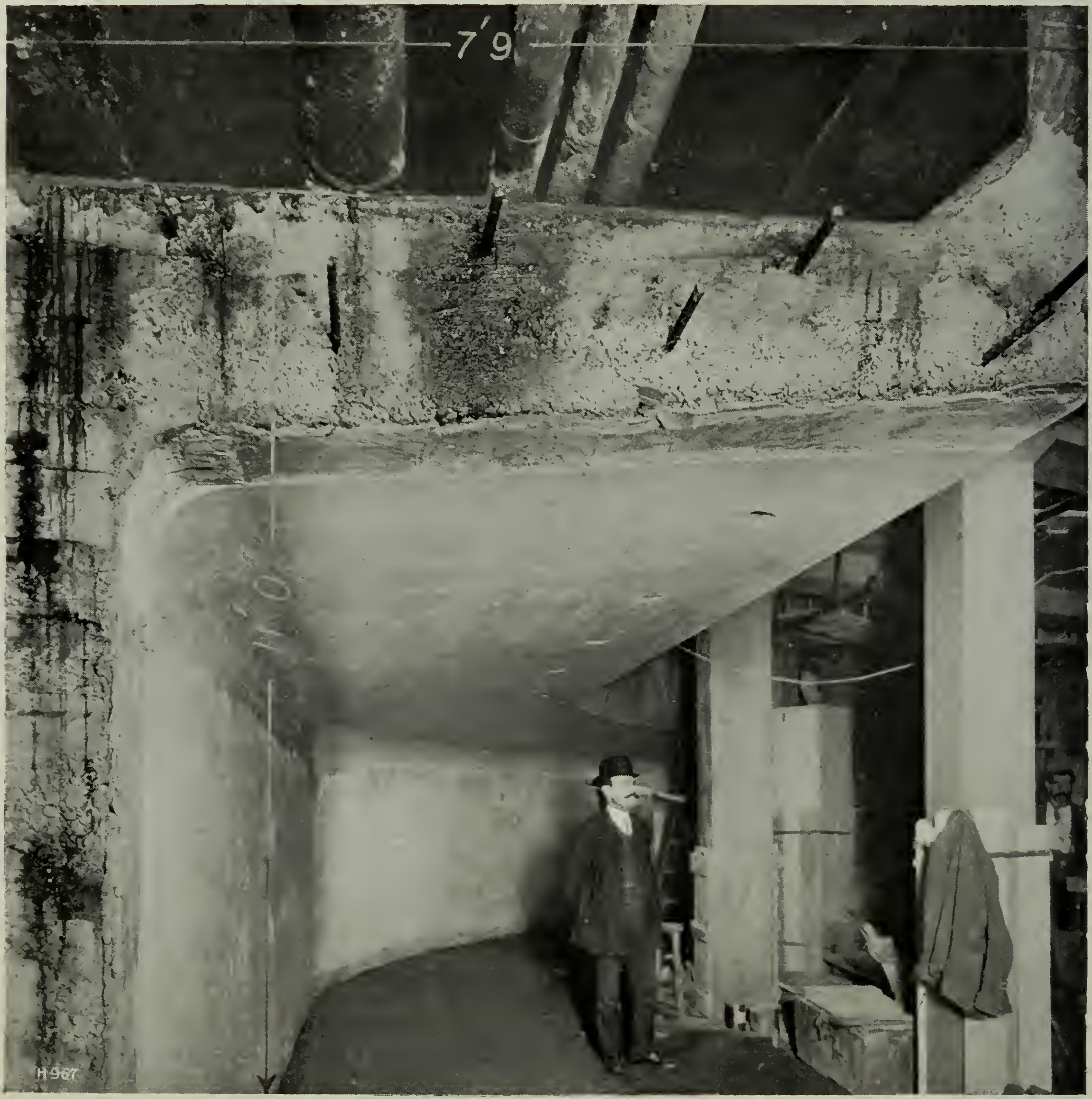
pile driver had to work close against several old walls badly cracked and out of plumb, no damage whatever was done by the piling.

A reinforced concrete capping was constructed on top of the piles forming a continuous girder underneath all walls, the reinforcement being placed so as to properly tie together the pile heads.

The architect for the work was H. E. Clifford, Esq., F.R.I.B.A., Glasgow, and the entire foundations were designed and carried out by Messrs. J. and W. Stewart, of London, Glasgow, Belfast and Dublin.

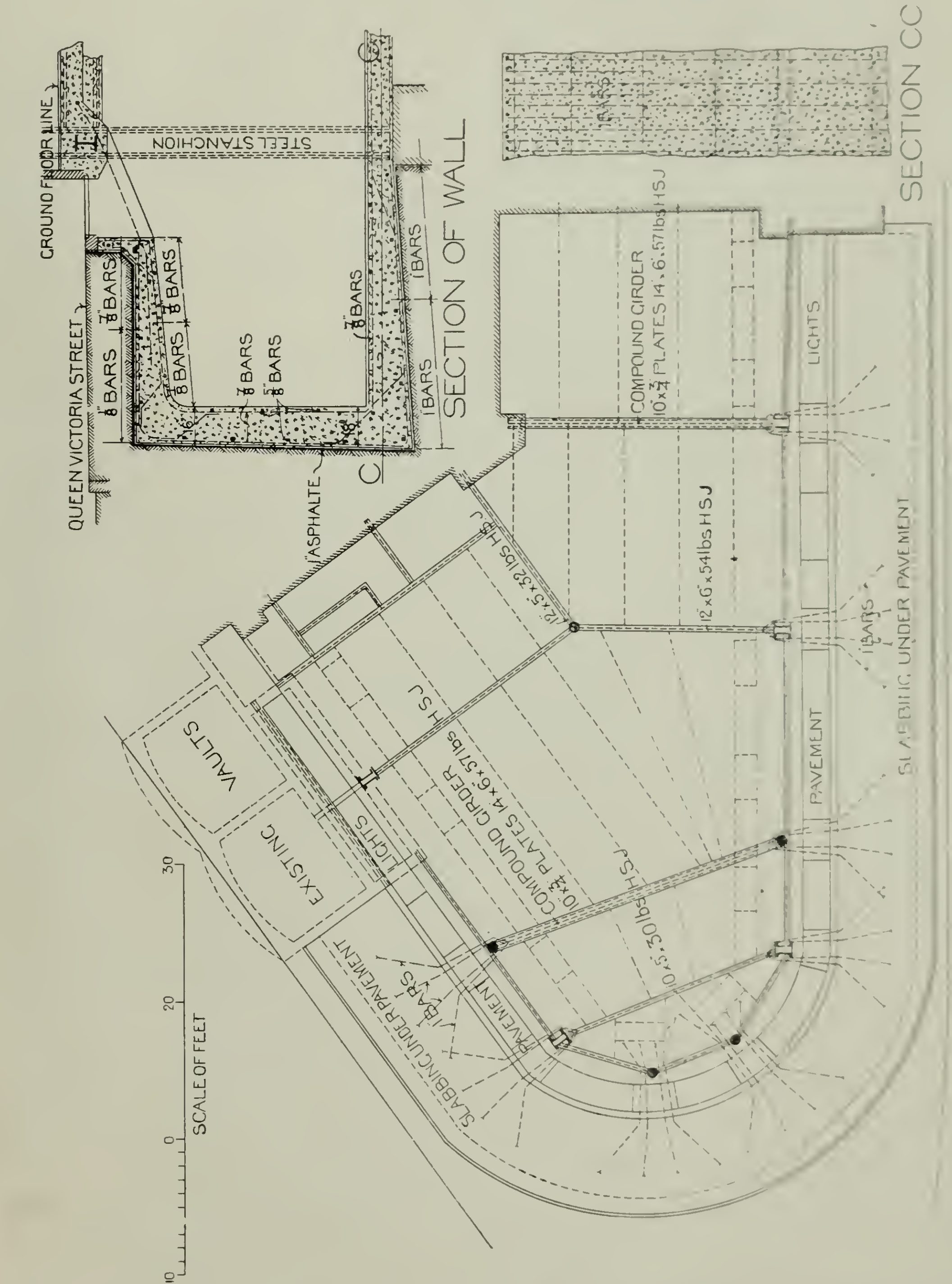
REINFORCED CONCRETE RETAINING WALL IN QUEEN VICTORIA STREET, LONDON, E.C.

Last month we illustrated a reinforced concrete retaining wall at the Royal Insurance offices in the City, and this month Messrs. D. G. Somerville and Co. send us particulars of a somewhat similar construction they recently carried out at Messrs. Mappin and Webb's premises at the corner of Queen Victoria Street and Cheapside. This corner, one of the busiest in the City, was entirely underpinned, and an extensive retaining wall and vaulting constructed, without in any way interfering with the traffic.



View in Course of Construction.
Reinforced Concrete Retaining Wall in Queen Victoria Street, London, E.C.

A feature of this construction was the cantilever slab, springing from the top of the retaining wall, carrying the pavement and finishing with small upstand which forms curb for pavement lights. The work, in view of the cramped working space and immense number of electric conducts, water mains, hydraulic pipes, etc., and the absolute necessity of not disturbing the traffic, presented great difficulties, but it was carried out successfully in a very short space of time.



Reinforced Concrete Retaining Wall in Queen Victoria Street, London, E.C.

The plan on this page shows the extent of the wall and vaults, while the section illustrates the cantilever which supports the pavement. This cantilever slab, extending 6 ft. 3 in. from the wall, is entirely unsupported, and is not in any way connected to the steel columns which carry the building. The wall itself, which retains the street, is 18 in. thick at base, tapering to 16 in. at top. When the enormous traffic of heavy motor vehicles is considered, the advantages of reinforced concrete are easily seen.

In addition to the mass of existing supply pipes which are clearly shown in the illustration on page 956 of the wall in course of construction, heavy timber shores, holding up the timbering, passed through the wall every 4 ft., and had to be boxed round as the concrete was placed in position. When the concrete was sufficiently set the struts were withdrawn and the openings made good. The underside, back of wall and top of slab forming the cantilever were asphalted on removal of the centering; and to give some idea of the difficulty of working space, special small-statured men had to be picked to do the work, there being only 18 in. of working room between the reinforced concrete wall and the timbering holding up the ground.

Indented bars, supplied by the Indented Bar and Concrete Engineering Co., Ltd., were used throughout for reinforcement, Alex. Drew, Esq., being the consulting engineer.

The architects for the building were Messrs. Belcher and Joass, Messrs. D. G. Somerville and Co., of 116 Victoria Street, Westminster, being responsible for the reinforced concrete work.

FOOTBRIDGE OVER RIVER SOWE, STAFFORD.

The Town Council having recently laid out Ornamental Pleasure Grounds on each side of the River Sowe, it was thought desirable to connect the two sections by means of a footbridge.

As the stretch of river passing through these grounds forms a very pleasing feature from the Victoria Road, which is the principal approach from the railway station to the centre of the town, it was important that care should be exercised in deciding upon a type of bridge which would be in keeping with and not detract from the beauty of the landscape.

It was also important that ample headroom should be provided under the centre of the bridge to enable decorated boats used in the water carnivals held on the river to pass under. As the river banks are only 18 in. above water-level, this headroom could not readily be obtained with a bridge having a horizontal soffit.

Schemes for various types of bridges were prepared, including a bowstring-girder bridge and a suspension bridge. A reinforced concrete elliptical-arched bridge, with pierced parapets, was eventually decided upon. An illustration of this bridge forms the frontispiece to this issue.

The bridge, including the abutments, decking parapets and end piers, is constructed entirely of reinforced concrete; it has a clear span of 56 ft., and is 6 ft. between the parapets, which latter are 3 ft. 6 in. high. The distance from the surface of the water to the soffit of the arch in the centre is 6 ft. 2 in.

As the subsoil for a considerable depth consists of soft peat, each abutment is supported on four reinforced concrete piles 14 in. square and 18 ft. long.

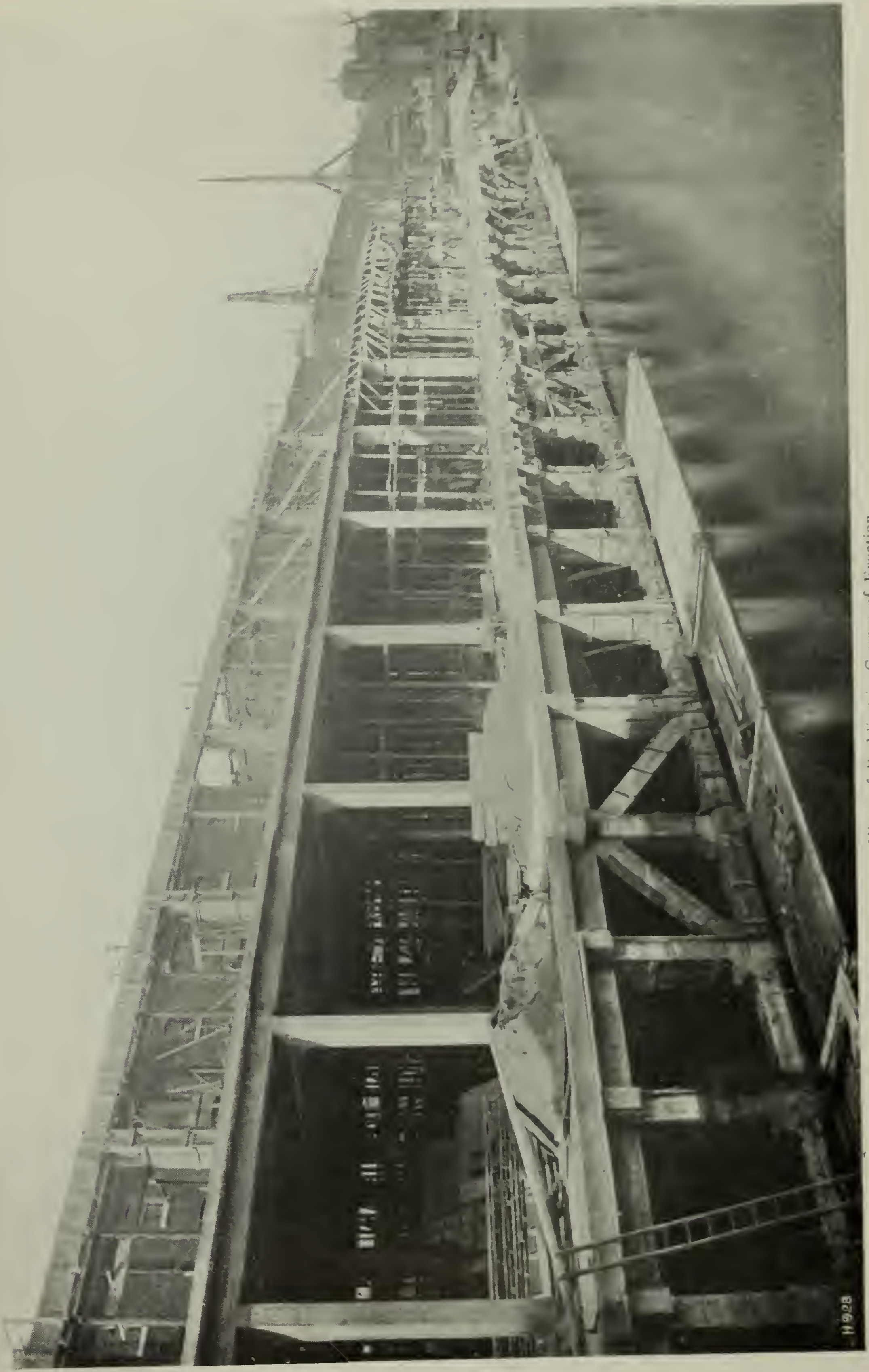
The bridge was designed to withstand a distributed load of 1 cwt. per foot super, and when the test load was applied the instruments showed a total deflection of $\frac{1}{10}$th of an inch, which disappeared when the load was removed.

The bridge has been built to the plans and under the supervision of Mr. W. Plant, A.M.Inst.C.E. The contractors for the work were the Yorkshire Hennebique Contracting Co., Ltd., of Leeds. The rendering of the whole of the exposed surfaces of the bridge was sublet to Messrs. James Morgan and Sons, a local firm. The reinforced concrete details were prepared by Messrs. Mouchel and Partners on the Hennebique principle.

Notwithstanding the fact that all unnecessary ornamentation was eliminated on the score of expense, the general lines of the bridge are very pleasing, as will be seen from our frontispiece, and it is generally admitted that the landscape has in no way suffered by the introduction of the bridge, but that it has been considerably improved thereby.

REINFORCED CONCRETE SHED AT THE LONDON DOCKS.

This new shed is being constructed on the North Quay for the Port of London Authority, and represents a building scheme of some magnitude. The Hennebique system of reinforced concrete has been adopted, and there is no doubt that such a material is admirably adapted for the particular class of work. The total length of the



View of Building in Course of Erection.

Reinforced Concrete Shed at the London Docks.

shed is about 1,260 ft. and about two-fifths of the scheme is practically complete;

the width of the site being 64 ft. 6 in., and the height of the building to the top of the reinforced concrete work from the dock bottom is 55 ft. 6 in.

The building itself is divided into five compartments, two of which measure 240 ft. long and three are 260 ft. long, these compartments being separated by brick walls having fire lobbies to ensure complete isolation in case of fire. There are two floors—viz., a ground floor at a height of 8 ft. 10 in. from the water-line, having a quay 15 ft. wide next the dock; and a first floor, which sets back to form a balcony 10 ft. 6 in. wide at a height of 16 ft. 2 in. above the quay, thus allowing goods to be easily transferred from the vessels to either floor in one operation with the travelling cranes which will be situated on the quay. Owing to the nature of the site, which adjoins the water, it was necessary to employ pile foundations, and these are about 16 in. square, reinforced with four round bars well tied with links at about 4-in. pitch.

There are about 480 piles in all, and those carrying the front of the quay are spaced at about 9 ft. 2 in. or 11 ft. 3 in. centres, being braced both longitudinally and crossways. The depth of water in which they stand is about 20 ft., and they are driven down for a distance of about 15 ft. below the dock bottom, this with their height above the water giving them a total length of about 44 ft. The floor of the quay was formed with $5\frac{1}{2}$ inches of reinforced concrete and 6 inches of plain concrete, this method allowing the rails for the travelling cranes to be placed on the top of the reinforced concrete, with the plain concrete filling around to give a level surface. The face of the quay is protected by 12-in. square pitch-pine fenders and bumping-posts to prevent damage by vessels.

The pile foundations under the building itself consist of similar piles driven in pairs at about 18 ft. 5 in. and 22 ft. 6 in. centres through the longitudinal direction, there being three rows of these across the building. The columns supported by these piles are 14 in. square, reinforced with four $1\frac{5}{8}$-in. bars, with steel links at 4-in. pitch. The angles of these columns are protected for a height of 3 ft. 6 in. from the floor-level by 3 in. × 3 in. × $\frac{3}{8}$ in. angle steels, let into the concrete to form a flush surface. The floor above is constructed with main beams 32 in. × 13 in. and 22 in. × 10 in., secondary beams 16 in. × 8 in. at 5 ft. 3 in. centres, and floor slabs 4 in. thick, exclusive of the 2-in. granolithic finish. The reinforcement of the slabs consists of $\frac{3}{8}$-in. bars at $5\frac{1}{2}$-in. centres, the alternate bars being turned up and passed over the beams, with $\frac{5}{16}$-in. bars at right angles to the main reinforcement at 12-in. centres. Access to the upper floor is provided directly from the external air only by means of spiral reinforced concrete staircases completely shut off from the ground floor. These steps were cast on the site and afterwards built in position, the tread and riser face being moulded in one operation, and strengthened with two steel bars. The necessity for a good light on the top floor led to the adoption of a saw-tooth roof, and this is being constructed in steel without the use of concrete. The external and division walls are formed in brickwork, and concrete was only introduced into the latter when great strength is required to carry cranes, etc. The concrete was machine mixed in the following proportions:—For columns, beams, floors and the like in the shed: One bag of cement (224 lb.), four and a half cubic feet of sand, nine cubic feet of aggregate. For all work in the quay: One bag of cement (224 lb.), three and three-eighths cubic feet of sand, six and three-quarters cubic feet of aggregate.

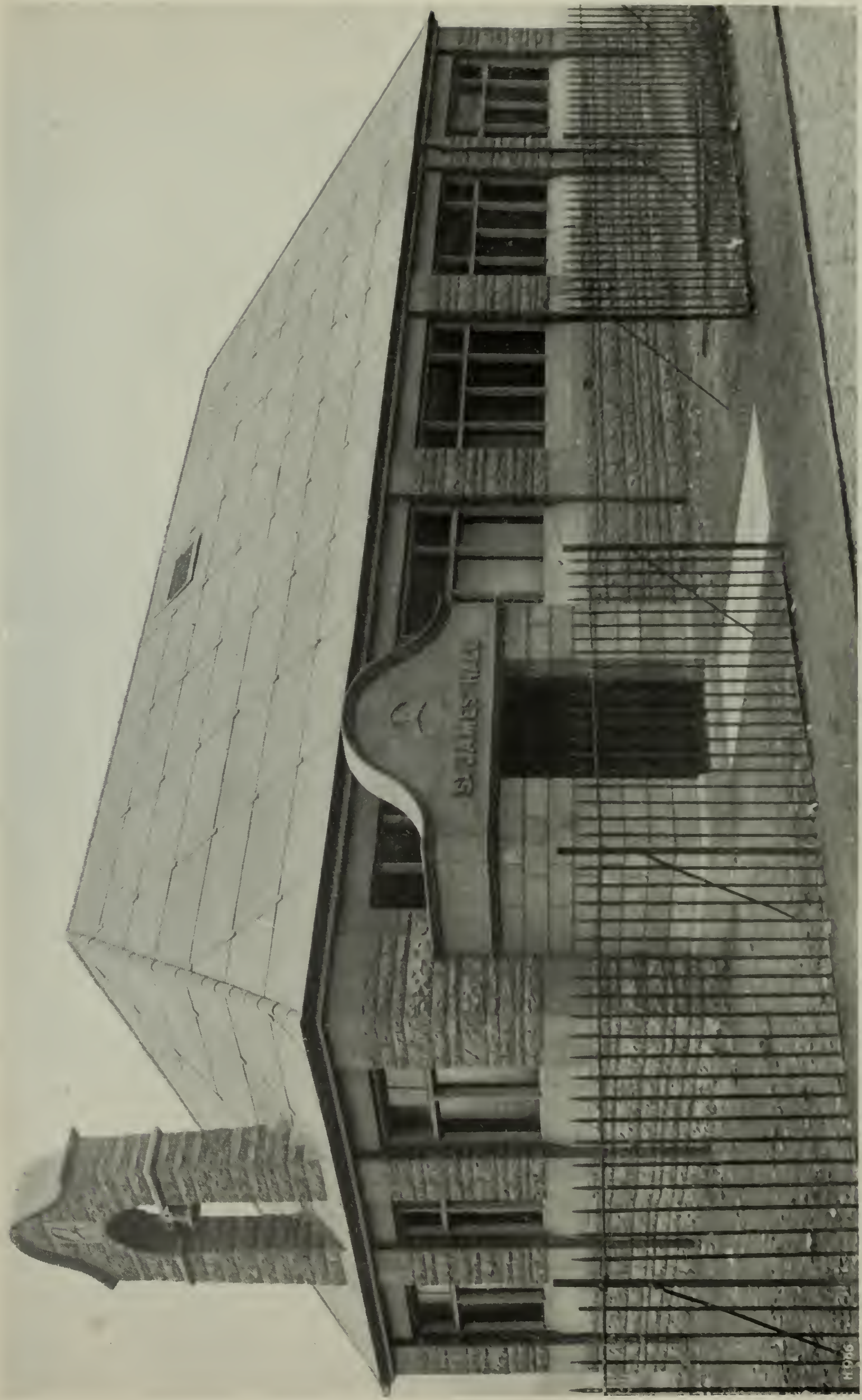
The contractors for the work are Messrs. Jackaman and Sons, of Slough.

ST. JAMES'S HALL, STOCKTON, BUILT OF CONCRETE BLOCKS.

THE St. James's Hall, Stockton, illustrated on page 961, was erected of concrete blocks throughout. It consists of one large room with a raised platform at one end, and has a seating capacity of 200 to 250 persons.

The hall is 64 ft. long, 25 ft. wide, 12 ft. high to the eaves, and 17 ft. to the ceiling. The walls are made of 14-in. hollow blocks, rock-faced on the outside and plain ashlar on the inside. No plastering or other material was needed on the walls, the use of concrete blocks thereby saving the cost of plastering, skirtings, moulds, etc.

The hall was opened on September 28th, and the structure has given universal satisfaction. It was designed by Mr. Arthur Harrison, architect, of Stockton, and was erected under his supervision.



Built of "Dring" Hollow Concrete Blocks.
ST. JAMES'S HALL, STOCKTON.

The concrete blocks throughout were made with the Dring's Patent Building Block machines supplied by the Stockton Stone and Concrete Co., Ltd., of Norton.

Interior of Building.
St. James's Hall, Stockton.

NEW USES FOR CONCRETE

AT HOME AND ABROAD.

Under this heading reliable information will be presented as to new uses to which concrete and reinforced concrete are put, with data as to experience obtained during the experimental stage of such new applications of these materials. The use of reinforced concrete as a substitute for timber in exposed positions is one of the questions of the moment. Railway sleepers, telegraph posts, fence posts, etc., of concrete are being tried. Similarly, efforts are at present being made to prove that reinforced concrete is an excellent substitute for brickwork where structures of great height are required.—ED.

REINFORCED CONCRETE CHURCH BUILT ON THE GROUND.

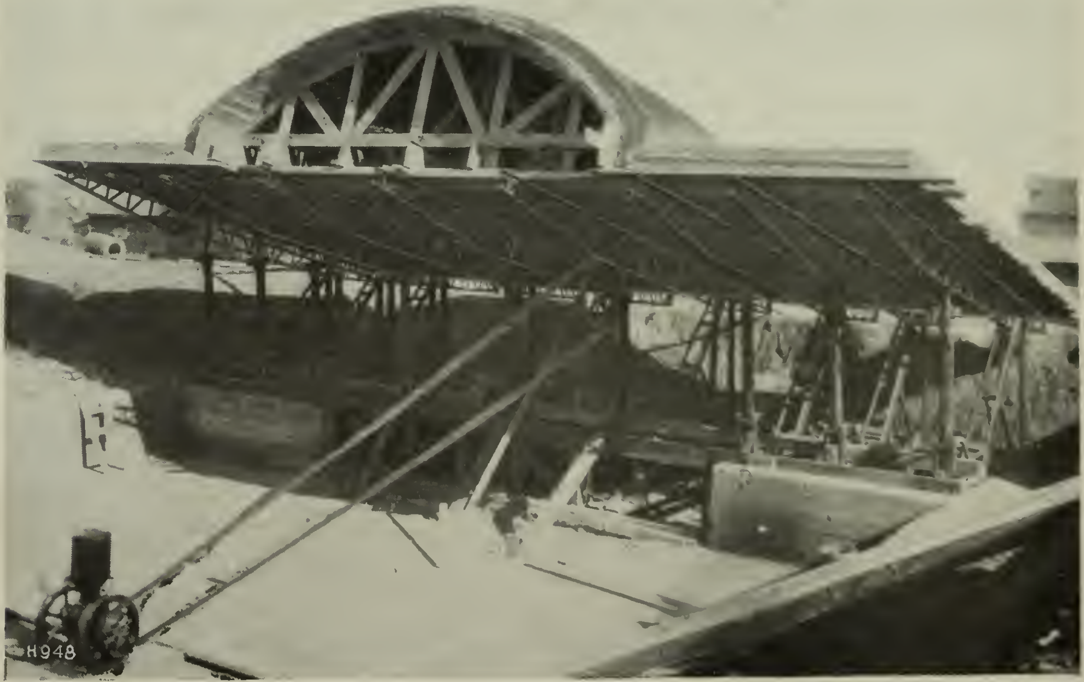
THE accompanying illustrations show a novel method of reinforced concrete construction, which consists, from an account in *The Scientific American*, of casting the walls on the ground and then raising them into position by means of jacks.

A series of jacks made of steel are set on the foundation wall and on piles inside of the building. These jacks consist of a supporting carriage, a pivoted walking beam, and a collapsible screw driven by a worm-gear and worm. A platform is laid on the jacks and on this platform are set in their proper relative positions all door frames, window frames and other openings.

The concrete is poured around the openings thus established, and the reinforcement is easily and properly placed horizontally and vertically in its exact position in both inner and outer walls. It is possible to use bars, wire-mesh, or any other kind of reinforcement desired. The entire wall is poured at once, which can be done in a single day, even though the wall be 200 ft. long and three storeys high.

After the wall is finished it is allowed to set for forty-eight hours, then a small gasoline engine or electric motor is connected with the driving shaft, and the wall rises from the inside slowly to its permanent vertical position. As soon as all the walls are placed the corners, where reinforcements from either wall project and interlock, are poured and there is formed a complete monolithic, well-finished structure.

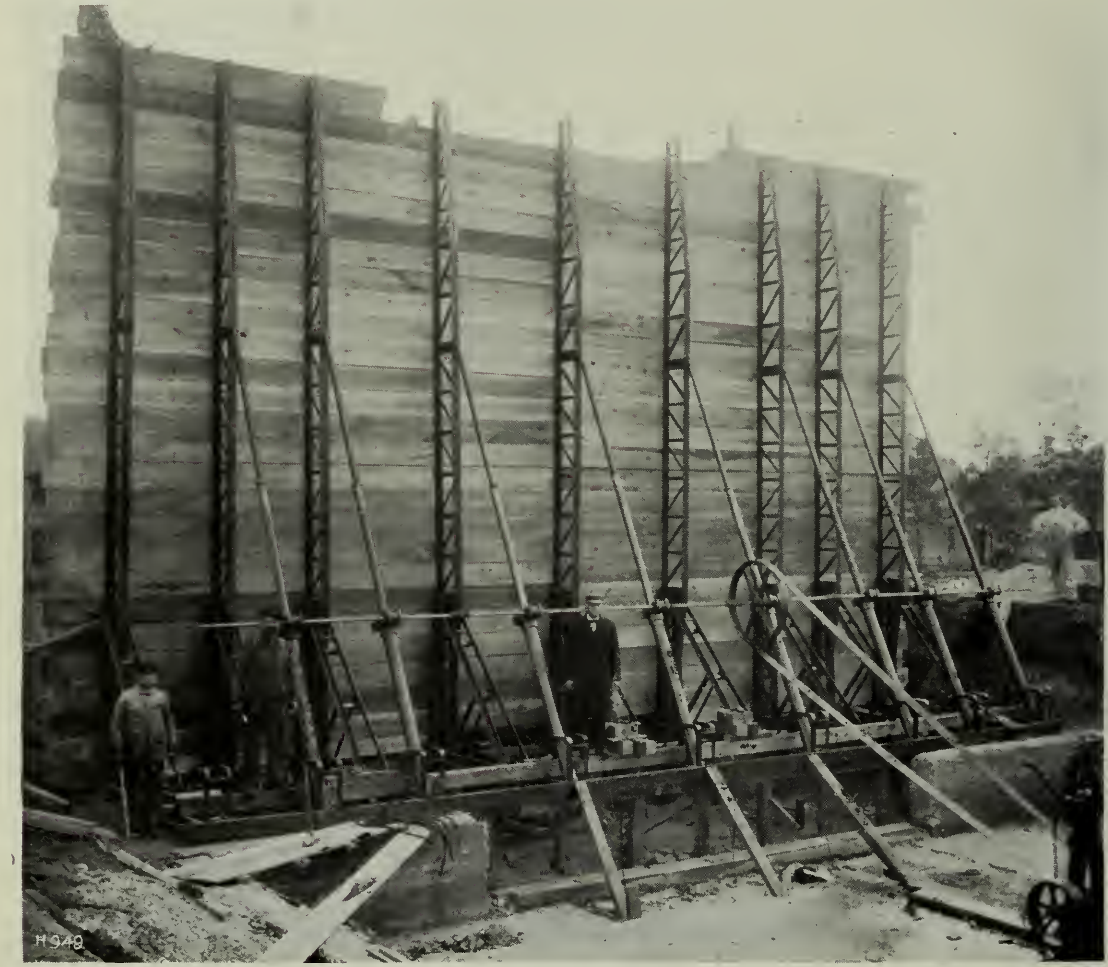
The floors and roof of concrete, or of any construction desired, are then put in



Raising the Wall.
REINFORCED CONCRETE CHURCH BUILT ON THE GROUND.

place in the same way as in any other building. There are no forms used whatsoever in this wall construction, except the wooden jack platform, which is not destroyed, but is used over and over again. There is an air space provided by filling in with loose sand, which is rodded out when the concrete sets and the wall is partially raised.

The building above described was carried out by the Monolithic Concrete Construction Co., of Chicago.



The Wall Jacked up.
Reinforced Concrete Church Built on the Ground.

MEMORANDA.

Memoranda and News Items are presented under this heading, with occasional editorial comment. Authentic news will be welcome.—ED.

Concrete Institute Events.—The programme of the Fourth Session of the Concrete Institute has just reached us—*i.e.*, some time after two of the most interesting events on that programme had taken place. We think that in future such announcements should take place not later than the end of September in each year.

The programme of future events is as follows:—

December 14th, 8 p.m.—Paper by Mr. G. C. Workman, M.S.E., of London, on "Some Recent Works in Reinforced Concrete."

January 11th, 1912, 8 p.m.—Discussion of the Report of the Reinforced Concrete Practice Standing Committee, embodying suggestions on "The Standardization of Drawings for Reinforced Concrete Work."

February 8th, 8 p.m.—Discussion of the Paper by Professor Beresford Pite, F.R.I.B.A., on "The Æsthetic Treatment of Concrete," which was read at the summer meeting in June, 1911.

March 14th, 8 p.m.—Discussion on the Interim Report of the Tests Standing Committee on "The Testing of Concrete, Reinforced Concrete, and materials employed therein."

April 11th, 8 p.m.—Subject to be subsequently announced.

May 9th.—Afternoon, 4.30 p.m.—Third Annual General Meeting.
Evening, 8 p.m.—Second Annual Dinner, at the Trocadero Restaurant, Piccadilly Circus, London.

There are, apparently, no new papers promised for this session, excepting one by Mr. G. C. Workman on recent works in reinforced concrete carried out by his firm (Edmond Coignet, Ltd.), all other events being devoted to subjects that have already been dealt with by the Institute for some considerable time past. We are glad to see that the second annual dinner has been arranged for members, and that this is to take place on May 9th, and we trust it will have the same excellent attendance which the previous one enjoyed last summer.

The British Fire-prevention Committee's Publications.—We understand that the British Fire-prevention Committee have decided to publish early next year an important illustrated tabular summary of the results of their official fire-tests, carried out on sixty fire-resisting doors. These results cover an experimental period of twelve years, and practically embrace every type of door, from different varieties of ordinary wood and hardwood doors to the most modern forms of composite and reinforced concrete doors. The summary will be published at £2 2s. (net). Later next year a similar summary dealing with fifteen different types of fire-resisting partitions will be published at 10s. 6d. (net), these partitions including some of concrete and reinforced concrete respectively. These publications will be issued over and above the usual reports and well-known "Red Books" of the Committee.

It should be pointed out that new subscribers to the Committee's publications enrolled at this period will have the benefit of a number of publications of quite exceptional importance, as well as those regularly issued by the Committee in the ordinary course, and it may therefore be of advantage to public authorities, professional men, and others to notify the Committee of their intended subscription at this stage.

The subscription to the publications, which figures at £2 2s. per annum, allows for use of the Committee's enquiry office, obtaining back issues of the 150 "Red Books" already issued at special figures, as far as they are still in print, and also of the summarised results of twenty-eight fire-tests with fire-resisting floors. Enquiries as to publications should be addressed in writing to the Assistant Secretary of the British Fire-prevention Committee, 8 Waterloo Place, London, S.W.

Advantages of Cement Mortar.— Cement nowadays enters so largely into building operations, owing in a great degree to the general adoption of fire-resisting construction, that it is surprising to find so few architects and engineers who specify walling to be constructed in cement mortar. In the case of light piers, or piers designed to carry heavy loads, the value of cement is readily recognised, and these sections of the work are marked out for special treatment. When the structure is in course of erection, the difficulty naturally arises as to unequal settlement—an anxiety which could easily be avoided by carrying out the whole of the work in cement. The material is now manufactured by first-class firms to such a high standard that it may safely be relied on, and if it be recollected that brickwork can bear twice the compressive strain when in cement than when in lime mortar, and that the difference in gross cost is at most 20 per cent., the actual saving incurred by using the latter material is not as substantial as is generally imagined. Building in cement, under normal conditions, frequently obviates the use of piers, and work can be proceeded with more expeditiously, while the elimination of settlement enables the vertical dimensions of any steelwork required to be calculated at once, and ordered directly the contract is signed, without the fear of having to make some readjustments at the last moment. Moreover, the walling is more durable and weather-proof. It would, therefore, seem a practical step to adopt cement mortar generally, except, perhaps, in those instances where everything has to be sacrificed to keep initial expenditure within the most strict and meagre limits.—*The British Architect.*

Cost of Industrial Buildings.— A useful comparison given in a paper contributed by Mr. J. P. H. Perry to the National Association of Cement Users (U.S.A.) relates to the cost of reinforced concrete, protected steel-frame, and "mill construction" factory buildings. The figures quoted were furnished by the tenders for buildings erected in various parts of the United States. Neglecting "mill construction," which finds no exact counterpart in this country, Mr. Perry's data show that the cost of reinforced concrete ranges from 2·8 to 13 per cent. less than that of fire-protected steel, the exterior walls being assumed to be of equal value.

The author justly urges, however, that initial outlay is not the only consideration, and that owners should also take into account the fixed annual charges, including interest, insurance, depreciation, the effects of vibration, and sanitation. Some saving in the first two items can probably be effected by reinforced concrete, and as the depreciation of the same material is not more than about 0·5 per cent. per annum, maintenance charges ought to be considerably reduced, while they would be vastly less than in buildings where steelwork is exposed to the air.

Freedom from vibration is one of the chief points of superiority characterising reinforced concrete as compared with steel-frame construction, and on this count Mr. Perry estimates the saving in machinery repairs to be one well worth attention. Among hygienic advantages he places resistance to the attack of vermin, and increased facilities for the admission of light.

Taking all things into account, the author urges that it would pay owners to adopt reinforced concrete even if the initial cost of the building were higher than that of a protected steel structure, and that the advantages of reinforced concrete construction are still more pronounced when compared with buildings erected in accordance with ordinary methods. The question is one quite deserving inquiry.—*The Builder.*

Extensions to Hydro, Harrogate.—Extensive additions are about to be made to the Cairn Hydro at Harrogate by the erection of an extra wing thereto, designed by Messrs. Bland & Bown, of Harrogate, in which reinforced concrete will be the predominating feature. The contract for this work has been obtained by the British Reinforced Concrete Engineering Co., Ltd., of Manchester.

New Reservoir for the Liverpool Corporation Waterworks.—The new reservoir for the Liverpool Corporation Waterworks will consist very largely of concrete, and when finished will have a capacity of over four million gallons.

The contract for the carrying out of this has been let to Messrs. Jowett Bros., of Burscough, after reinforced specialists had prepared schemes for same in accordance with the Liverpool Waterworks Engineer's instructions.

New Co-operative Stores, Cleckheaton.—The Yorkshire Hennebique Company, of Leeds, have obtained the contract for the reinforced concrete work in the New Co-operative Stores that are to be erected at Cleckheaton.

Reinforced Concrete Verandah.—A reinforced concrete verandah is to be erected on the west side of the Hôtel Métropole at Blackpool, in accordance with the requirements of the borough authorities.

Reinforced Concrete at St. Helens.—Messrs. Pilkington Bros., Ltd., owners of the St. Helens Glass Works, contemplate making considerable additions thereto, and firms engaged in reinforced concrete work have been asked to submit scheme and estimates for the carrying out of such work.

Cheapness of Concrete Schools.—The real value, showing the actual cheapness, of concrete has again been most strongly emphasised in the Liverpool district, when recently new schools were erected at Walton at a cost of from £8 to £9 per head per scholar against what has been the average cost of from £11 to £12 per head when buildings have been erected in brick and stone materials.

Cost of Church Building.—The above subject has recently been very much discussed in *The Manchester Guardian,* wherein Sir W. Holdsworth has been advocating the possibility and probability of erecting such at a cost of something like £7 per person to be accommodated. It is surprising how slow architects generally are to adopt reinforced concrete for church work, as we have given instances from time to time, notably in the Free Church at Hampstead, of the economy and efficiency of reinforced concrete for such structures.

Reinforced Concrete Design.—The prizes of the Leeds and Yorkshire Architectural Society were presented at their last meeting, when that for construction was awarded to Mr. W. Volkel for a design in reinforced concrete for an entrance hall and main staircase to a public building. His design was considered to show great merit and usefulness, and demonstrated to what immense advantage reinforced concrete can be applied in works of this kind.

Influence of Transport on the Properties of Concrete.—A novel industry lately originated in some German cities is the preparation and supply of ready-mixed mortar and concrete. These materials are prepared in special works and transported thence to building works in progress. There can be no doubt that the plan of mixing under expert supervision should be beneficial in itself; while, on the other hand, it is to be feared that the delay inseparable from loading, transport and delivery may affect the setting of the mortar and concrete, and that the jolting of concrete on the way from the mixing works may cause segregation of the constituents. In order to obtain reliable data on the two points in question, tests have been conducted on a series of specimens of concrete taken before and after transport. According to the results furnished by the tests, it appears that the transport of concrete actually increased the strength of the material by about 15 per cent., the increase being more noticeable in cases where aggregate with sharp edges had been employed. We are reluctant to accept this conclusion for general guidance, and, besides, it is highly probable that in ordinary practice delays would occur in delivery, presenting considerable risk of inferior work.—*The Builder.*

Designing a Concrete Construction Plant.—Mr. Sanford E. Thompson, the well-known American consulting engineer, and an associate of Frederick W. Taylor in the application of scientific management to construction plants, says of the designing of a concrete plant:

"On all work of such magnitude as to make the use of a concrete machinery mixing and handling plant expedient, it is of great importance in the matter of speed and economy to have the entire plant well designed and planned out to the best

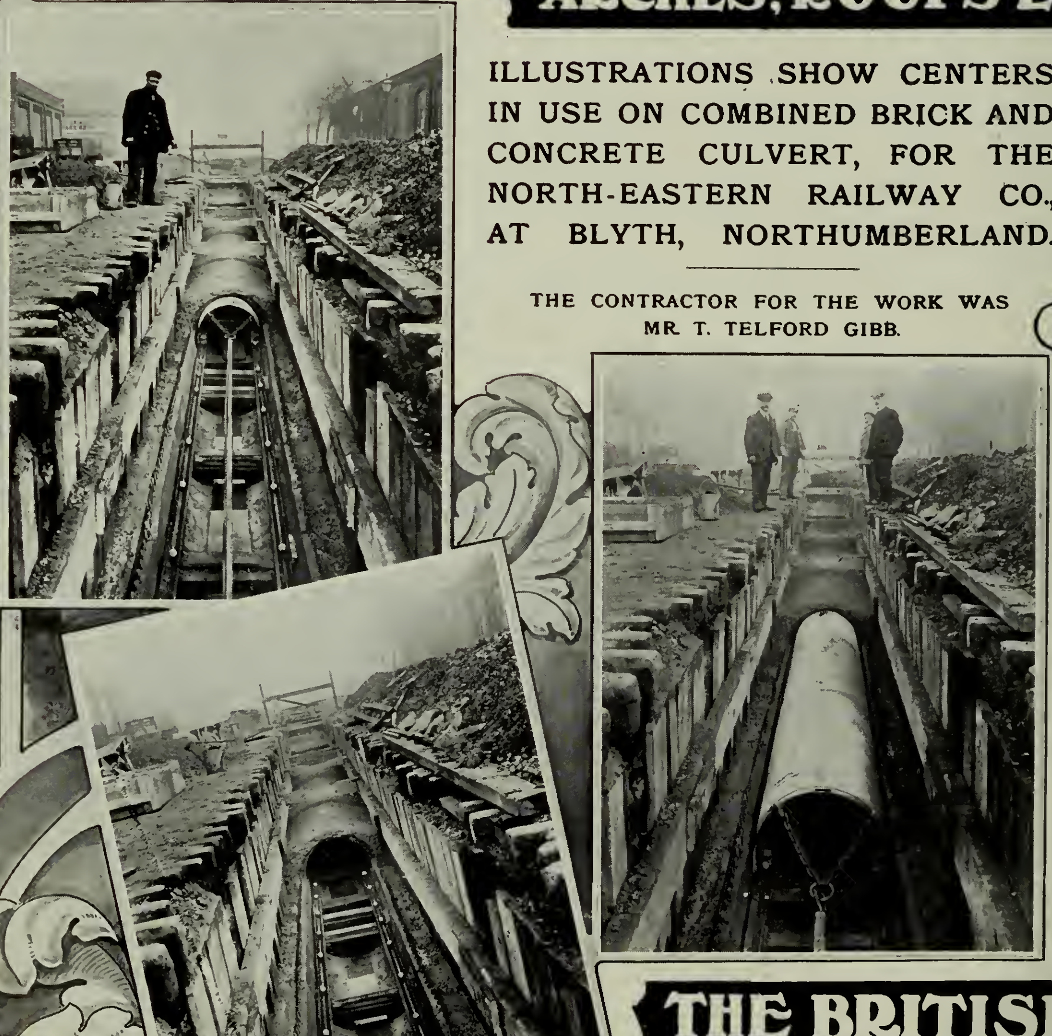
BLAW COLLAPSIBLE STEEL CENTERING

CHEAPER & BETTER THAN TIMBER — MORE EASILY HANDLED — BETTER FINISH ON THE CONCRETE.

FOR SEWERS, CULVERTS, CONDUITS, ARCHES, ROOFS E^TC

ILLUSTRATIONS SHOW CENTERS IN USE ON COMBINED BRICK AND CONCRETE CULVERT, FOR THE NORTH-EASTERN RAILWAY CO., AT BLYTH, NORTHUMBERLAND.

THE CONTRACTOR FOR THE WORK WAS MR. T. TELFORD GIBB.



THE BRITISH STEEL PILING COMPANY,

DOCK HOUSE,
BILLITER S^T
LONDON. E.C.

advantage. And this design must of necessity vary according to the nature of the work, the way in which raw materials can be brought to the plant, the natural features of the ground where the plant is to be located, the cost of materials delivered on the job for constructing the plant, the time in which the work must be completed, the amount of money there is in the job, and any special conditions that may exist in connection with the work. Even where the general features of the plant are practically the same for two different jobs the details are usually more or less at variance. Therefore, it means careful and thorough study and efficient planning effectively to meet the conditions, so as to prevent waste of money and to decrease cost. The design of the plant for handling the raw materials for concrete and for conveying the concrete to place usually has more to do with economy in mixing than the particular type of mixing machine. As there are plenty of good mixers, engines and other machinery on the market, the particular make used is, in a measure, a matter of personal choice, or is determined by what can be economically had at any given location, either new or bought from some previous job. The proposed plant should be drawn or sketched on paper, and the cost and expense of installation, as well as of operation, estimated as accurately as possible, so as to determine whether the volume of concrete to be laid is sufficient to warrant the construction and operating expense. The authors have seen expensive machinery, which could not be transported readily to another job, installed on a section of work where hand-mixing would have been actually more economical because of the small total volume of concrete and its distribution over a large area. Usually the important points to plan for are what shall be used for handling the machinery and the concrete : whether cableways ; belt conveyors ; elevators of various kinds ; cars hauled by dinkies, by horses, or by hand on level tracks ; cars hauled by cable on inclines or derricks ; whether trestles shall be built, and to what extent ; whether the mixers can be so located that raw material can be dumped direct to bins from standard gauge cars ; whether the mixing plant shall be mounted complete on trucks or cars ; or whether some special combination of a part or all these shall be used. The minimum amount of concrete that will make it advantageous to instal a machinery mixing and handling plant is variable, depending on the nature of the work and local conditions to such an extent that it must be carefully figured out for each. On some jobs 500 cu. yds. would be the minimum, while on others it might possibly be as high as 1,500."

TRADE NOTICES, ETC.

Hydrofuge Castor Waterproofing. — Messrs. H. Elliott & Co., of County Bank Chambers, Ealing, London, W., have recently brought to our notice their Hydrofuge Castor, which is a liquid bituminous product, for mixing with cement and sand in concrete and plaster work, and which the makers claim renders these absolutely waterproof, even when subjected to the highest pressure.

The principal advantages put forward for Hydrofuge Castor waterproofing is that it stops up cracks and fissures, prevents efflorescence entirely, and adheres perfectly to old work. It withstands the injurious influences of salt and acidulated water, and permits of painting and papering being done after a very short time.

It should be extremely useful for underground railways, tunnels, subways, and viaducts, as it dries up underground premises liable to damp and floods, also for foundation dampcourses, covering damp walls, fronts and gables exposed to heavy rain ; for waterproofing sea- and water-works, water channels, dams, canals, etc. It is also used for floors, walls, and vats of breweries, tanneries, dyehouses, stables, washing-rooms, and for all sanitary and hygienic installations.

For years it has been a matter of deep study on the part of engineers, architects, and others to discover a means of preventing the inroads of damp, and the consequent rusting of the metal in reinforced concrete structures, but the proprietors of Hydrofuge Castor boldly claim that their material is specially suitable for this purpose, and forms an absolutely permanent waterproof coating, which can be applied to existing structures at a very moderate cost. This is a claim the importance of which will be recognised by the whole building world, and it would seem that this new material is destined to become a most important factor in reinforced concrete work generally.

The method of using Hydrofuge Castor is extremely simple, and, moreover, very economical, as a small proportion of the castor is required to make the mortar or concrete permanently waterproof. The directions for use are as follows :

PROPORTION.—To every 100 lbs. of Portland cement allow 5 lbs. of Hydrofuge Castor. It is prepared and applied like any ordinary plastering.

EXAMPLES.

1. For works exposed to heavy or driving rains	100 lbs. cement 300 lbs. sand 5 lbs. castor	Two to three coats. Total thickness, 5/8 to 7/8 of an inch
2. For works in contact with water, but not subject to pressure, such as floors, arches, &c.	100 lbs. cement 200 lbs. sand 5 lbs. castor	Three coats, each being not less than 1/4 inch
3. For works exposed to pressure, such as cellars, sea-works, reservoirs, &c.	100 lbs. cement 100 lbs. sand 5 lbs. castor	Three coats, each being 5/16 of an inch

Messrs. Elliott & Co. will be pleased to post full descriptive pamphlets to all interested in this material.

Messrs. Richardsons, Billiter Square Buildings, London, E.C., have, we understand, just been appointed London representatives of Messrs. Tait & Co., Kobe, Japan, who are opening an engineering department.

Firms desirous of finding a market for their manufactures in Japan and the East should send their catalogues in duplicate to Messrs. Richardsons' Export Department.

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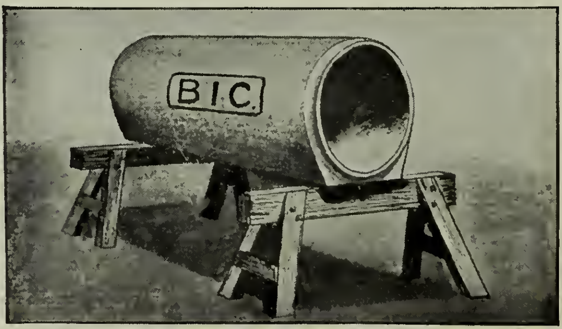

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